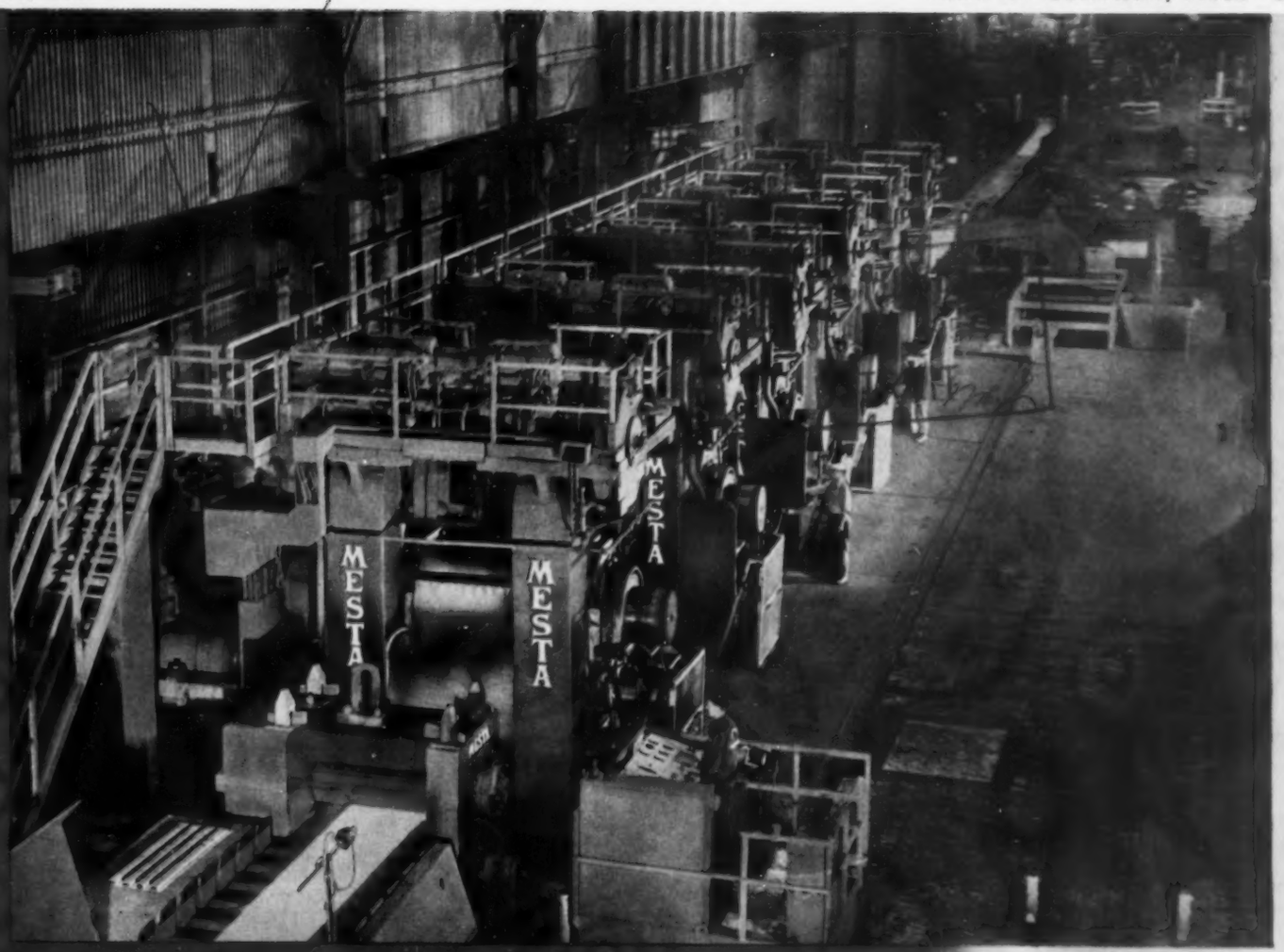
# Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

AUGUST, 1957


TABLE OF CONTENTS, PAGE 3




MESTA 56" Four-High Hot Strip Mill for Rolling Stainless, Silicon, High-Alloy, and Carbon Steels at Allegheny Ludlum Steel Corporation


HOT STRIP MILLS

Designed and Built by MESTA

*Designers and Builders of Complete Steel Plants*

**MESTA MACHINE COMPANY**

PITTSBURGH, PENNSYLVANIA

* * *

# For Your A-c Mill Auxiliaries Save with Cutler-Hammer Unitrol

**Standardized Modular Construction**

All control units are 20" wide and in multiples of 14" in height. This permits easy interchange of various sizes and types of control units without rearrangement of the entire control assembly and avoids wasting space with dead panels to adapt non-uniform control units. This standardized modular construction also insures good appearance at all times because horizontal lines match.

When you need control for A-c mill auxiliaries such as pumps, fans, blowers, conveyors, etc., be sure to check the savings you can make with Cutler-Hammer Three-Star Unitrol. This modern control equipment provides important economies from the moment it is delivered!

Cutler-Hammer Unitrol often saves days, even weeks, in the time required for installing control. It saves the delay and the high cost of mounting and wiring numerous individual starters. Its compact design saves valuable space in the mill. Any one of these savings may pay the entire cost of Unitrol!

In performance, nothing compares with Unitrol. Its extra-life *vertical* contacts stay clean and trouble-free, never require maintenance care or expense in all normal use. Its adjustable overload coils let motors work harder safely, avoid both motor damage and needless work interruptions. Full three-phase protection by three-coil overload relays is easily included whenever desired.

Write or wire today for your copy of the Unitrol book, EL-174. No obligation. CUTLER-HAMMER, Inc., 1269 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER-HAMMER

* * *

UNITROL

C-H

Unitrol plug-in feature disconnects control from power when unit is moved to test position, reconnects without misalignment when unit returns to operating position. Control panel is *always* vertical. Plug-in design permits back-to-back assemblies without staggering control units. Units are removed by merely disconnecting load and control wiring at terminal boards. This wiring is cabled, marked and color coded.

Unitrol provides either circuit breakers or fused disconnect switches of advanced design. Both have three-position self-aligning operators arranged for padlocking with as many as three locks in the "off" position. Recessed pushbuttons and concealed door hinges are typical features that add to safety and fine appearance.

*The name UNITROL is a Cutler-Hammer trade mark*

Components front of panel mounted without stacking. No crowding, no power connections near panel fasteners. Many Three-Star Control exclusives. Superlife vertical contacts *never* require maintenance expense in all normal control uses. Adjustable overload relay coils let motors work harder with safety. Full Three-Phase Protection with 3-Coil overload relays on standard size starter panels.

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# The Spirit of a Company

•

How do you measure or evaluate the spirit of a company?

By physical facts — size, number of plants, number of employees?

Or by accomplishments — the amount of sales, the outstanding installations, the new products?

Or by the intangibles — the reputation, the respect of the industries served, the interest of the company in their customers?

No one ever has defined specifically the spirit of a company, yet every company with which you do business has a certain identifying spirit.

•

What is the spirit of Aetna-Standard as we see it ourselves?

The ability to do a job well.

The courage to design equipment in the face of competitive bidding without diluting the ruggedness and the extra components for the sake of a price.

The strength to pioneer in ideas.

The perseverance to say "no" when "yes" would be much easier.

The awareness of the importance of customers.

## The Aetna-Standard Engineering Company

Ellwood City, Pa. Pittsburgh, Pa. Warren, Ohio.

# CONTINUOUS STRIP ANNEALING LINES

## WHEN *Experience* COUNTS

*Two of five Wean Continuous Strip Annealing Lines installed in a Pittsburgh district mill.*

### *Ninth Wean Engineered Line Sets New Record*

The ninth Wean designed continuous strip annealing line for silicon and tinplate products is now in the process of construction. This means that Wean has engineered more of these lines than all other firms combined — a record in every sense of the word.

The reasons for this Wean leadership are many. For example, the Wean design permits maximum speed and production while providing an excellent bright annealed product of uniform surface. And, users of Wean continuous lines report better metallurgical control, better temper mill operation with elimination of stickers, better delivery and a reduction in process inventory.

★ Wean also has designed and built 11 Stainless Steel Continuous Annealing Lines — also a record in the industry.

58

THE WEAN ENGINEERING COMPANY, INC. WARREN, OHIO

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# Iron AND Steel ENGINEER

AUGUST, 1957 VOLUME XXXIV NUMBER VIII

## In This Issue

*Crops and Shorts* ..... 11
*Patent Reviews*—By Melvin Nord, Patent Attorney, Detroit, Mich. ..... 25
*Increasing Open Hearth Capacity*—
*Fuel's Contribution to Increased Open Hearth Capacity*—By C. W. Dunn, Superintendent, Utilities Dept., Fairless Works, United States Steel Corp., Fairless Hills, Pa. ..... 57
*Increasing Open Hearth Capacity by Extending the Hearth*—By Charles D. Guth, Furnace Design Engineer, Lukens Steel Co., Coatesville, Pa. ..... 64
*Increasing the Capacity of an Open Hearth Shop*—By M. K. Morris, Assistant Superintendent, No. 2 and No. 4 Open Hearth Shops, Bethlehem Steel Co., Bethlehem, Pa. ..... 69
*Solvent Degreasing—A Valuable Industrial Process*—By W. L. McCracken, Director of Research, Detrex Corp., Detroit Mich. ..... 73
*Automation in the Production of Rail Joints*—By C. E. Chapman, Superintendent, Rail Accessories Dept., Inland Steel Co., East Chicago, Ind. ..... 81
*Distribution System Studies in Steel Mills*—By D. Dalasta, General Engineer, and Frank Nolan, Application Engineer, Switchgear Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis. ..... 87
*Crowned Tooth Gear Type Couplings—Development and Application for the Steel Industry*—By Frank W. Zurn, Vice President, American Flexible Coupling Div., Zurn Industries, Inc., Erie, Pa. ..... 98
*Current AISE District Section Meeting Notices* ..... 116
*The Facility Round-Out Program At Columbia-Geneva*—By Harold G. Degitz, Staff Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif. ..... 117
*Program, 1957 AISE Annual Convention* ..... 121
*A New Static Control System*—By Frank C. Fennell, Manager, Central Region Engineering, Westinghouse Electric Corp., Pittsburgh, Pa. ..... 125
*Something New in Sintering*—By Harold E. Rowen, General Manager, Patrick V. Gallagher, Vice President, and Thomas E. Ban, Director of Research, Dwight-Lloyd Div., McDowell Co., Inc., Cleveland, Ohio. 133
*E. W. Bliss Company Reaches Century Mark* ..... 147
*Jacks Reduce Machinery Erection Time* ..... 151
*Allegheny Ludlum Puts Large Vacuum Furnace into Operation* ..... 155
*Okonite Company Opens New Plant* ..... 157
*Date-line Diary* ..... 165
*Industry News* ..... 175
*Personnel News* ..... 195
*Equipment News* ..... 215
*Book Reviews* ..... 225
*Index to Advertisers* ..... 231

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# DRAVO-LURGI sinter plants convert iron ore fines to usable form

Two new sinter plants, with a combined annual capacity of over 10,000,000 tons, are being built by Dravo. Each plant will contain three huge sinter machines for processing iron ore fines into clinkers suitable for charging blast furnaces.

Through an exclusive licensing agreement with the Lurgi Company, Europe's foremost builder of sinter machines, Dravo Corporation's extensive engineering and construction facilities are combined with Lurgi's design experience. The new plants now under construction are a result of this combination.

Dravo's engineering and construction skills play an important part in making new processes and techniques available to industry. For information on any of the products or services listed below, write DRAVO CORPORATION, PITTSBURGH 22, PENNSYLVANIA.

**DRAVO**
CORPORATION

Blast furnace blowers • boiler & power plants • bridge sub-structures • cab conditioners • docks & unloaders • dredging • fabricated piping

foundations • gantry & floating cranes • gas & oil pumping stations • locks and dams • ore & coal bridges • process equipment • pumphouses & intakes

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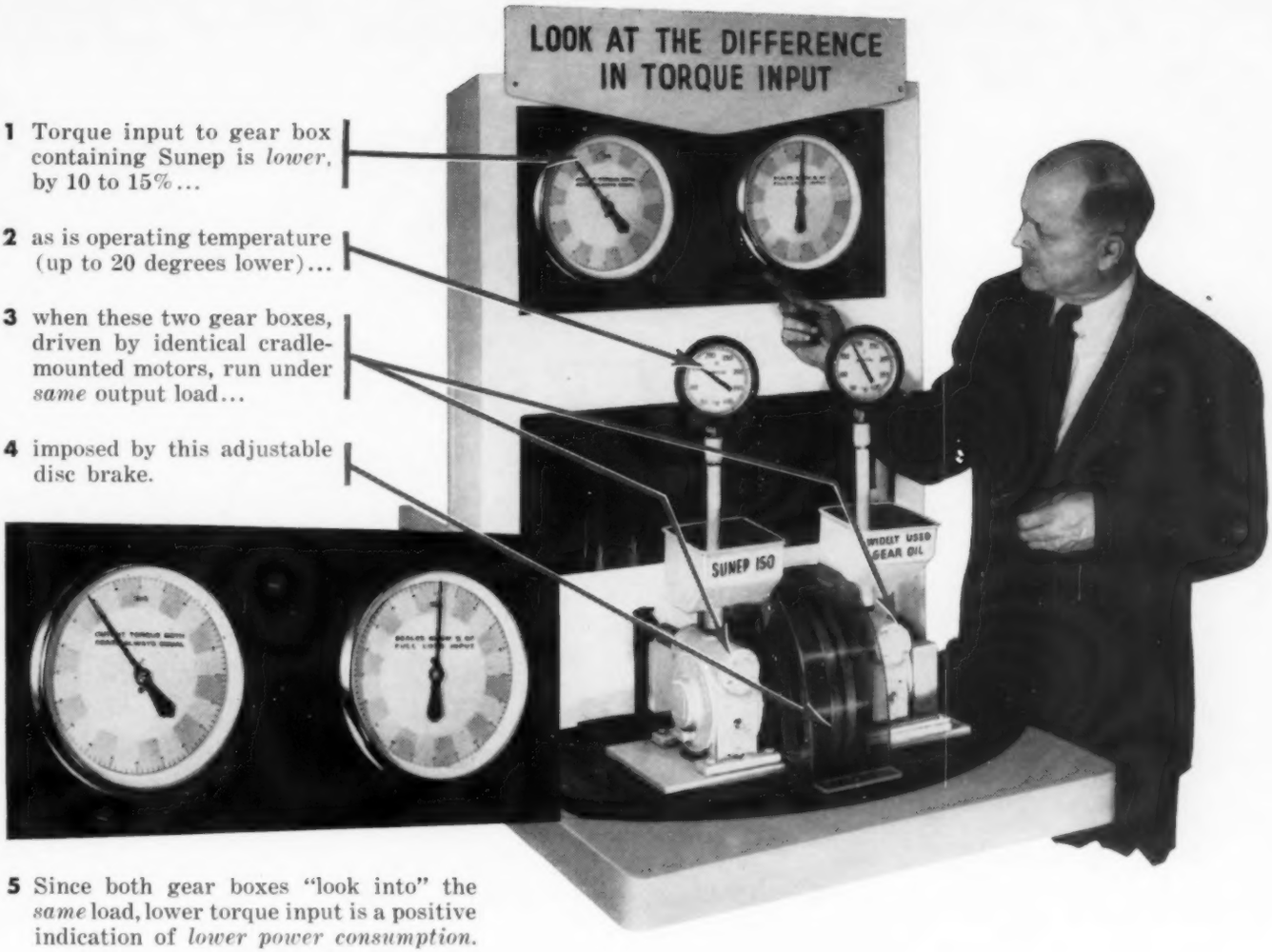
LOOK AT THE DIFFERENCE IN TORQUE INPUT
1 Torque input to gear box containing Sunep is *lower*, by 10 to 15%...
2 as is operating temperature (up to 20 degrees lower)...
3 when these two gear boxes, driven by identical cradle-mounted motors, run under *same* output load...
4 imposed by this adjustable disc brake.
SUNEP 150
WIDELY USED GEAR OIL

5 Since both gear boxes "look into" the *same* load, lower torque input is a positive indication of *lower power consumption.*

*This test rig proves...*

# SUNEP CUTS POWER CONSUMPTION, REDUCES OPERATING TEMPERATURES

TIME AND AGAIN, under equal operating conditions, Sunep® gear lubricant has demonstrated its superiority over competitive oils. Sunep is a high-quality, extreme-pressure lubricant that is also recommended for screws and heavily loaded bearings.

In addition to extreme-pressure characteristics, Sunep has the ability to combat rust and corrosion. All additives are compatible and do not drop out during use or prolonged storage. These advantages add up to savings in money and equipment for you.

For complete information about Sunep oils, call your Sun representative or write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. IS-8.

**INDUSTRIAL PRODUCTS DEPARTMENT**

**SUN OIL COMPANY** Philadelphia 3, Pa.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO AND MONTREAL

SUNOCO®

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# A SLIGHTLY FANTASTIC success story...

## Lee Wilson Single Stack Annealing Furnaces outsell all others 10 to 1

Most steelmakers can remember when it was believed that multiple stack annealing was the answer to greater production. But little more than a decade ago, Lee Wilson engineers developed high connection annealing and found the best medium of this high-speed method to be the single stack furnace.

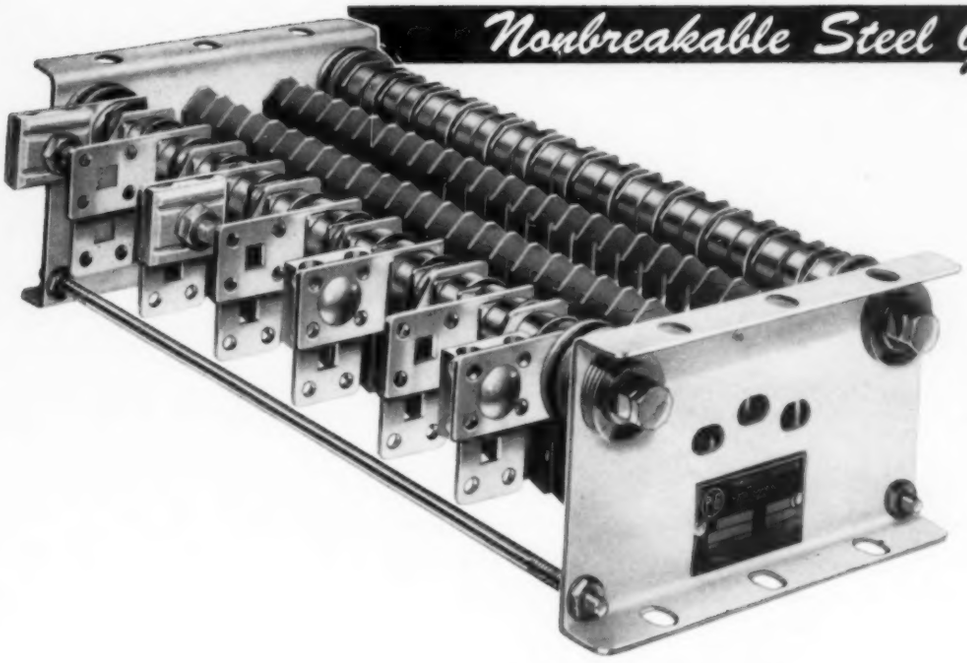
At first, steelmakers were reluctant to accept a smaller furnace. However, production figures and quality checks proved the single stack high convection system vastly superior to old style methods, and soon all leading steel producers were experimenting with pilot installations.

Today, the single stack is outselling multiples all along the line—and Lee Wilson is outselling all others 10 to 1. The answer is simple. The single stack has proved itself to be a better annealing method and, Lee Wilson, the originator, naturally knows more about single stacks than any other manufacturer.

# when PERFORMANCE

## IS IMPORTANT TRY . . . POST-GLOVER

### *Nonbreakable Steel Grid Resistor*



- All Steel Construction
- Mica Insulation
- Corrosion Resistant
- Unaffected by Vibration or Moisture
- Provision for Expansion
- Adequate Ventilation
- Rugged Terminals

### *Rugged*

Built of Steel and Mica—nothing to break. Light in weight yet dependable. Remarkably constant resistance values regardless of temperature or age.

### *Original Grid Design*

Provides a shape assuring maximum ventilation. Heat is evenly distributed. With all parts of grid equally exposed, heat is rapidly dissipated.

### *For any job*

Where constant "trouble free" resistor service is wanted . . . you can safely specify P-G Steel Grid Resistors and get better performance with lower maintenance.

**P-G *has* BOTH!** STANDARD Resistors — WELDED Resistors

*The Nonbreakable Steel Grid Resistor*

P-G

ESTABLISHED 1892

THE **POST-GLOVER** ELECTRIC COMPANY

OFFICE and FACTORY—Kenton Lands Road, Erlanger, Kentucky

MAILING ADDRESS—Box 709, Covington, Kentucky

*Because the mortar*

# Harbison-

# more than 25 different

Refractory brick structures last longer when the bonding mortar matches the characteristics of the brick. The mortar should correspond with the brick in refractoriness, thermal expansion and other properties and should be compatible in chemical composition. To fulfill the requirements for the many different types and classes of refractory brick and operating conditions, Harbison-Walker produces more than twenty-five bonding mortars.

Included in this wide range are some mortars which set with a strong bond upon drying, which is retained at high temperatures, and others which acquire a good ceramic set only when heated. The

*Some of the Various Types and Classes*

| BRAND | DESCRIPTION | TYPICAL APPLICATIONS |
|---|---|---|
| HARWACO BOND<br>wet or dry | Cold-Setting with strong bond and negligible shrinkage—alumina-silica composition—more refractory than any mortar of fireclay base. | Used for laying all classes of fireclay and high alumina brick in boiler settings—kilns—oil refining units—metallurgical furnaces. |
| HARWACO MASTIC<br>wet or dry | Corresponds to HARWACO BOND in composition—especially adapted for use in thick plastic consistency. | For pointing or sealing cracks in brickwork—as a protective coating—monolithic packing back of water-wall tubes—air duct linings. |
| CORALITE BONDING MORTAR<br>wet | High alumina cold-setting cement of unusually high refractoriness. | For laying all classes of alumina-silica brick used at unusually high temperatures in contact with molten metals and various corrosive slags. |
| KORUNDAL BONDING MORTAR<br>dry | Cold-setting bonding mortar containing approximately 85% alumina. Mineral composition mullite and corundum. Extremely high in refractoriness. | Used for laying all classes of high-alumina brick. Very resistant to corrosion by volatile alkalies and slags of certain metallurgical furnaces. |
| H-W CORUNDUM BONDING MORTAR<br>dry | Substantially an all corundum cold-setting mortar of 99% alumina content. | The ultimate in refractoriness among high alumina mortars—used with greatest benefit at highest temperatures. |
| THERMOLITH<br>dry | Chrome base cold-setting mortar. Highly resistant to many very corrosive fluxes. | Most extensively used for laying magnesite, chrome and forsterite brick. Also favored for use with fireclay and high alumina brick in many special applications. |

**HARBISON-WALKER REFRACTORIES COMPANY**
AND SUBSIDIARIES

*World's Most Complete Refractories Service*

**General Offices: PITTSBURGH 22, PA.**

*is as important as the brick . . .*

# Walker provides BONDING MORTARS

mortars with hot-setting properties contribute to flexibility in expansion and contraction of structures which are subjected to soaking heats throughout. Chemical compositions vary from highly basic, through various degrees of neutral to strongly acid, and in each specific case provide for maximum resistance of the joints to the widely different corrosive slags and fumes. Among these compositions are those consisting largely of magnesia, forsterite (magnesium silicate) chrome, corundum (stabilized crystalline alumina), silica and alumina-silica in various ratios.

Adequate refractoriness to secure the most durable and impervious joints and smooth-working plasticity with proper water retention are other properties of major importance for these mortars.

In addition to the different kinds described in the following table, Harbison-Walker produces others, including hot-setting mortars such as H-W FURNACE MAGNESITE, H-W SPECIAL FURNACE CHROME, H-W BONDING MORTAR and various brands of finely ground high duty and super-duty fireclays as well as several modifications of silica cements and mortars primarily for laying insulating fire brick.

From these bonding mortars can be selected those best suited for each specific application to secure longest furnace life and greatest economy.

## *of Harbison-Walker Bonding Mortars*

| BRAND | DESCRIPTION | TYPICAL APPLICATIONS |
|---|---|---|
| H-W FORSTERITE BONDING MORTAR dry | Strong cold-setting, magnesium silicate mortar of basic character. | For use at high temperatures with H-W FORSTERITE brick in glass-melting and various metallurgical furnaces. |
| H-W PERIKLASE BONDING MORTAR dry | Basic, highly refractory, cold-setting mortar used for laying H-W PERIKLASE and other basic brick. | Used in electric and open hearth steel melting furnaces, glass furnaces, rotary kilns. |
| FIREBOND dry | Siliceous cold-setting bonding mortar having the property of high resistance to siliceous slags. | Used for laying silica brick where strong bonded joints are desirable and with fireclay brick for dense impervious joints at moderate temperatures. |
| VEGA BOND dry | Hot-setting silica cement of super-duty quality. Non-shrinking and smooth working. | For laying and grouting conventional and super-duty silica brick in all their applications. |
| ANKORITE dry | High alumina hot-setting mortar possessing excellent working qualities. Provides flexibility to brickwork in soaking heats over an intermediate temperature range and a strong set at the furnace operating temperatures. | Used for laying super-duty and high duty fireclay brick and the various classes of high alumina brick where a highly refractory heat setting mortar serves to best advantage. |
| H-W WEATHERED BOND B CLAY dry | Hot-setting bonding mortar. Excellent plasticity and bonding qualities developed by a long weathering process. | Used with splendid results for laying fireclay brick in boiler settings, iron blast furnaces and stoves. |

***Use this coupon to get prices and additional information about Harbison-Walker Bonding Mortars***

Harbison-Walker Refractories Co.
Pittsburgh 22, Pa.

Please send me prices and information about the following bonding mortar(s)

_____

_____

NAME_____ POSITION_____

COMPANY_____

ADDRESS_____

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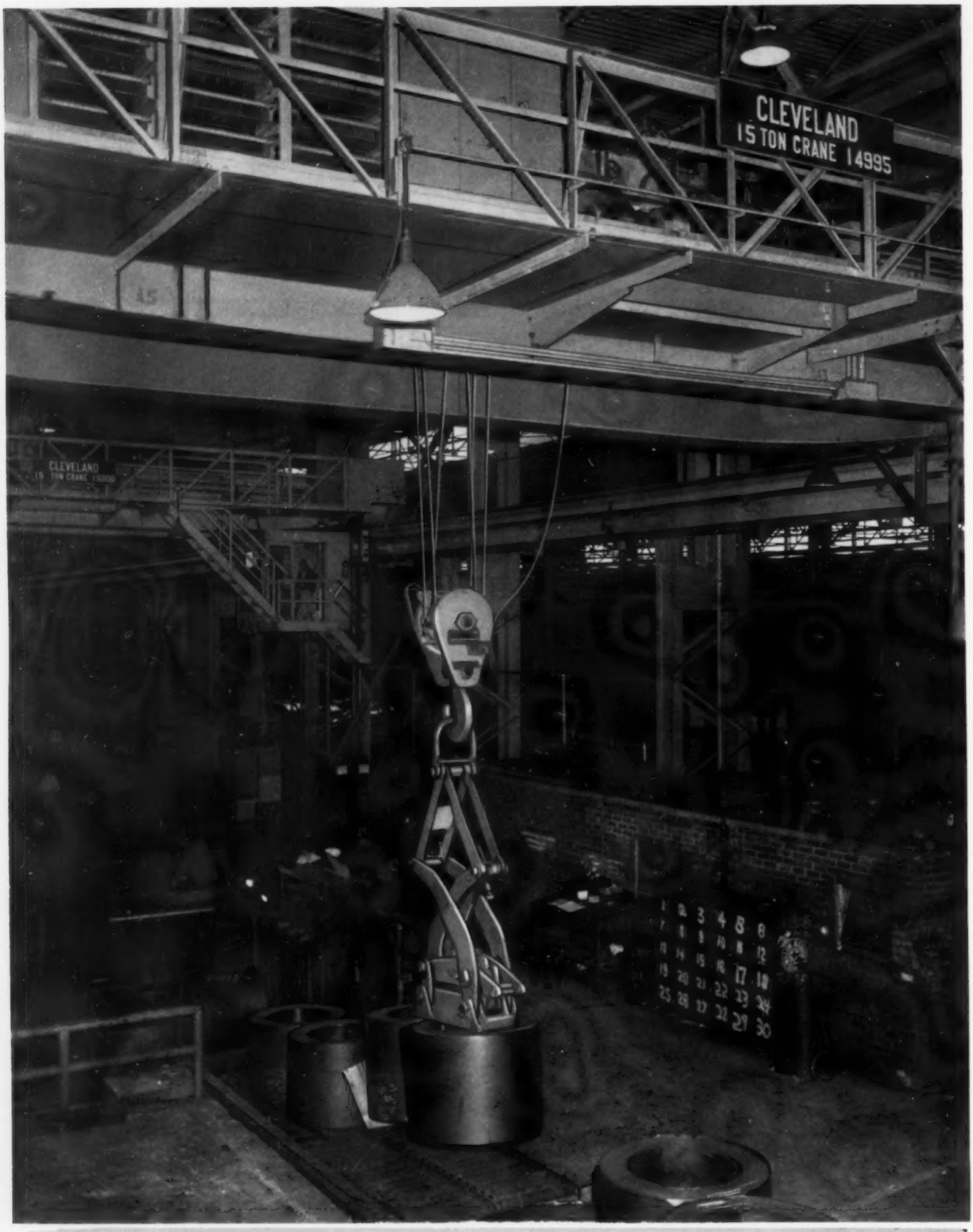



# CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

# Crops *and* Shorts

STEEL production for the first half of 1957 totaled 60,586,145 net tons of ingots, outranked only by the first half of 1956. In the total were 54,329,561 net tons from open hearths, 1,492,272 net tons from bessemers and 4,764,312 net tons from electric furnaces.

It is interesting to note that, in spite of the wailing about business, it won't take too much of a pickup in the last quarter to bring the year's production up close to our 1955 record of 117,000,000 tons.

▲

JUST in case you're feeling too prosperous, remember that the net public and private debt at the end of 1956 totaled $684,000,000,000—$4000 for every man, woman and child in the nation.

▲

A FRIEND of ours who has taken the cigaret-health controversy very much to heart says he tried substituting gum for cigarets but couldn't keep the darn stuff lit.

▲

WHAT with the great efforts put into recruiting young engineering graduates, even to the point of giving summer vacation jobs to undergraduates, it's surprising to find one or two cases where steel plant trainees were put on reduced time (and pay) during the drop-off in operations. There's no better way to lose them—and earnings don't exactly indicate necessity of the move.

▲

WE ARE advised to look for the debut of tablets that, dropped in a glass of water, explode into a flavored, carbonated drink. They will be flavored cherry, lime, orange and grape. What about beer, bourbon, scotch and gin?

▲

THERE are more than 800,000 building fires in the United States each year. Principal causes: smoking and matches—15%; heating and cooking equipment—12.5%; electrical—12.4%; rubbish—7.5%; flammable liquids—5.7%. October 6–12 is Fire Prevention Week.

▲

THE little boy who could never remember what his mother sent him to the store for has now grown up and is in Congress.

▲

THE importance of oxygen in the steel industry is indicated by the 1956 consumption figure, which totaled 23,901,000,000 cu ft, almost one-half of the production in the United States. About two-thirds of the steel industry consumption was purchased, the other third coming from the industry's own plants. In recent years, at least 30 oxygen plants have been installed on or close to steel plant sites. About 30 new plants will go into operation during the next two years.

▲

SPEAKING of depreciation problems, a power company in Missouri had to pay $13,000 to tear down a smokestack that was built in 1921 for $8700.

▲

AN ULCER specialist advises that we'd all be better off if we quit being a "beller" and became a "what-the-heller."

▲

ACCORDING to the American Iron and Steel Institute, the iron and steel industry came up with a disabling injury frequency rate in 1956 lower than ever before. The record shows 3.83 disabling injuries per million man-hours worked, 8 per cent below the 1955 figure and 40 per cent below the all-industry rate for 1956. Over the past 30 years, the steel industry has lowered its rate nearly 82 per cent. During the same period the all-industry figure declined slightly more than 75 per cent.

▲

IT USED to be that labor unions struggled for the workers' right to join a union. Now, by overriding a workers' right *not* to join the union, unions have actually changed the *right* to join to a mandate.

▲

HARD work never really killed anybody but it seems to scare a lot of people half to death.

▲

THE trend toward longer college courses would be almost completely unnecessary if the schools would effectively impress on each student that study and education should not stop when the student leaves school.

▲

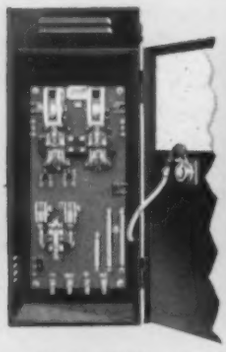
YOUR getting older when you feel your corns more often than your oats.

# Get more work from *any* magnet

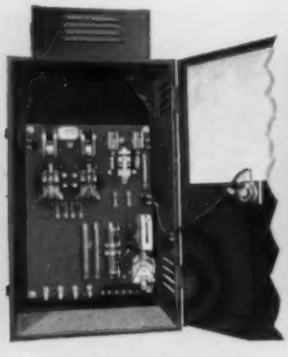
# with EC&M MAGNET CONTROLLERS

## ADJUSTABLE...for Faster, cleaner release of loads

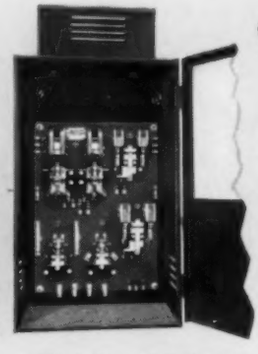
EC&M Magnet Controllers deliver top performance with magnets of all types and makes. They discharge loads quickly and cleanly. There is no "dribble." Magnets "work" more because faster drops eliminate "positioning" the magnet at point of discharge... A simple, two-position (Lift-Drop) Master Switch provides exceptionally easy operation. Because power is off, automatically, when the switch is in the "drop" position, there is no overheating to reduce high lifting capacity. Longer magnet life is another important bonus.



**Type AD Standard Controller** for single magnets or two magnets in parallel. Exclusive, adjustable discharge for different type loads



**Booster Controller** gives increased pull-away power from pile, then carries load at reduced current



**High Speed Release DLM-335-A Controller** reduces the discharge time of deep-type magnets 50%

***Bulletin 905** gives complete description of EC&M Controllers for use on lifting magnets of all types and makes*

***Write** for your copy*

**THE ELECTRIC CONTROLLER & MFG. CO.**

*A DIVISION OF THE SQUARE D COMPANY*

CLEVELAND 28 • OHIO

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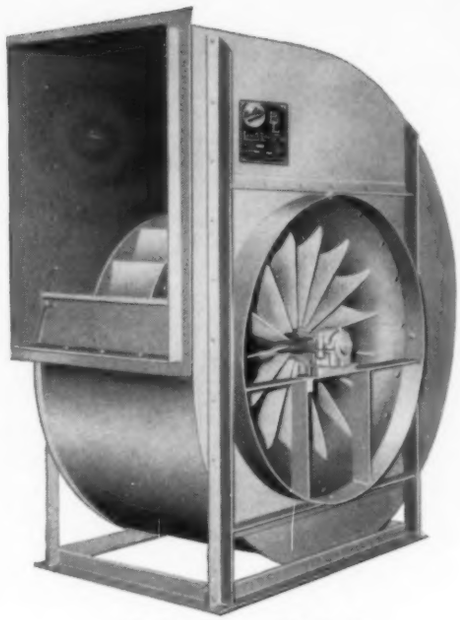


*(Buffalo Type "BL" Fan)*

# HOW "BUFFALO" FANS GIVE YOU MORE ECONOMICAL MILL MOTOR COOLING

Ventilation for motor rooms and motors presents a potent challenge to any fan. It's a continuous high-temperature air moving operation... 24 hours a day, day in and day out, year in and year out.

"Buffalo" Fans are built to stand up under this kind of punishment. Take the type "BL" Fan, shown above. Its rugged, durable construction features insure you a long life of peak heavy-duty performance with a minimum of maintenance.

These "Buffalo" features include over-sized, self-aligning bearings — heavy plate housing — rigid plate wheel with husky hub, back plate and die-formed blades. You're sure of full-rated-delivery-on-the-job because of the exclusive "Buffalo" design of the complete unit... from fixed inlet guide vanes through the wheel to the discharge.

These are all good reasons why the "Buffalo" Type "BL" Fan will give you more economical and reliable mill motor cooling. Contact your nearest "Buffalo" Engineering Representative for details, or write for Bulletin F-102.

If your mill motor cooling fans must be placed in a confined area, "Buffalo" Axial Flow Fans are the ones to specify. Their light weight, rigid construction permits economical installation. They effect important space-savings because they fit in snugly to walls, ceilings, or floors. Ideally suited to duct or through-the-wall installation. Either direct or belt drive.

Whether you install your own axial flow fan, or have it installed as a component, be sure you specify "Buffalo" for maximum reliability and economy. Write today for Bulletin 3533-H.

*Engineered into every "Buffalo" Fan is the famous "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

*(Buffalo Axial Flow Fan)*

"Buffalo"

**BUFFALO FORGE COMPANY**

BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING AIR CLEANING AIR TEMPERING COOLING HEATING INDUCED DRAFT EXHAUSTING FORCED DRAFT PRESSURE BLOWING

HAGAN RING BALANCE FEATURES—NO. 1

## TRIGONOMETRY OF UNIQUE RANGE CALIBRATION SYSTEM PROVIDES HIGH SENSITIVITY AT LOW FLOWS

Low-flow sensitivity is a built-in feature of the Hagan Ring Balance flow meter. Rotation of the ring, in response to differential, is governed by the adjustable range spring in accordance with the unvarying trigonometry of the range calibration mechanism. This is expressed by the formula:

$$\text{Spring deflection} = R(1-\cos\theta) - L(1-\cos\phi),$$

and is graphically illustrated at the right. The upper curve shows that the ring motion at low range exceeds the requirement to produce pen motion linear with flow. Thus, the cam which transmits ring motion to the pen arm can convert this excess ring motion into extra power for precise pen movement.

**METERING APPLICATIONS WHICH REQUIRE WIDE TURN-DOWN CALL FOR HAGAN RING BALANCE METERS.** You get this feature when you specify Hagan, as well as the following:

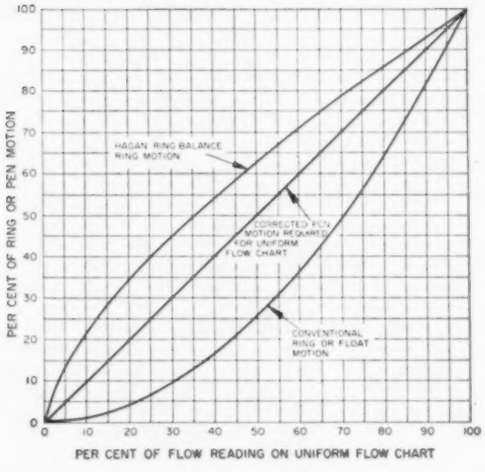
1. Ease of calibration under operating static pressures with factory calibrated check weights! No more four-story water columns and telephones!
2. Safe operation with rings rated at 2,500, 10,000, 15,000 psig. No gaskets, no stuffing boxes.
3. Sealing fluid density and level not critical. No eyedroppers required.
4. Interchangeable ring assemblies for full scale ranges from 0.5" w.c. to 560" w.c. Adjustment on any one ring over a 7:1 differential range.
5. Wide range computation and/or compensation by means of built-in, easily checked mechanisms available on most models.
6. Pneumatic or electric transmission also available.

Bulletin MSP-141 describes these features and the new design of the Hagan Ring Balance meter case. ASK US FOR IT.

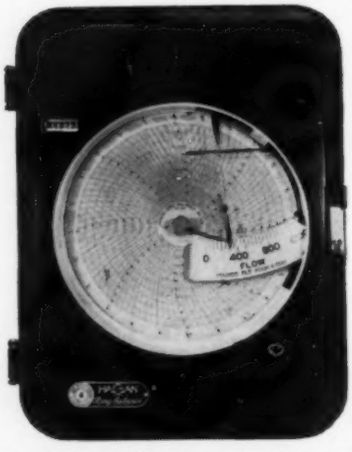
**HAGAN CHEMICALS & CONTROLS, INC.**

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY • HALL LABORATORIES

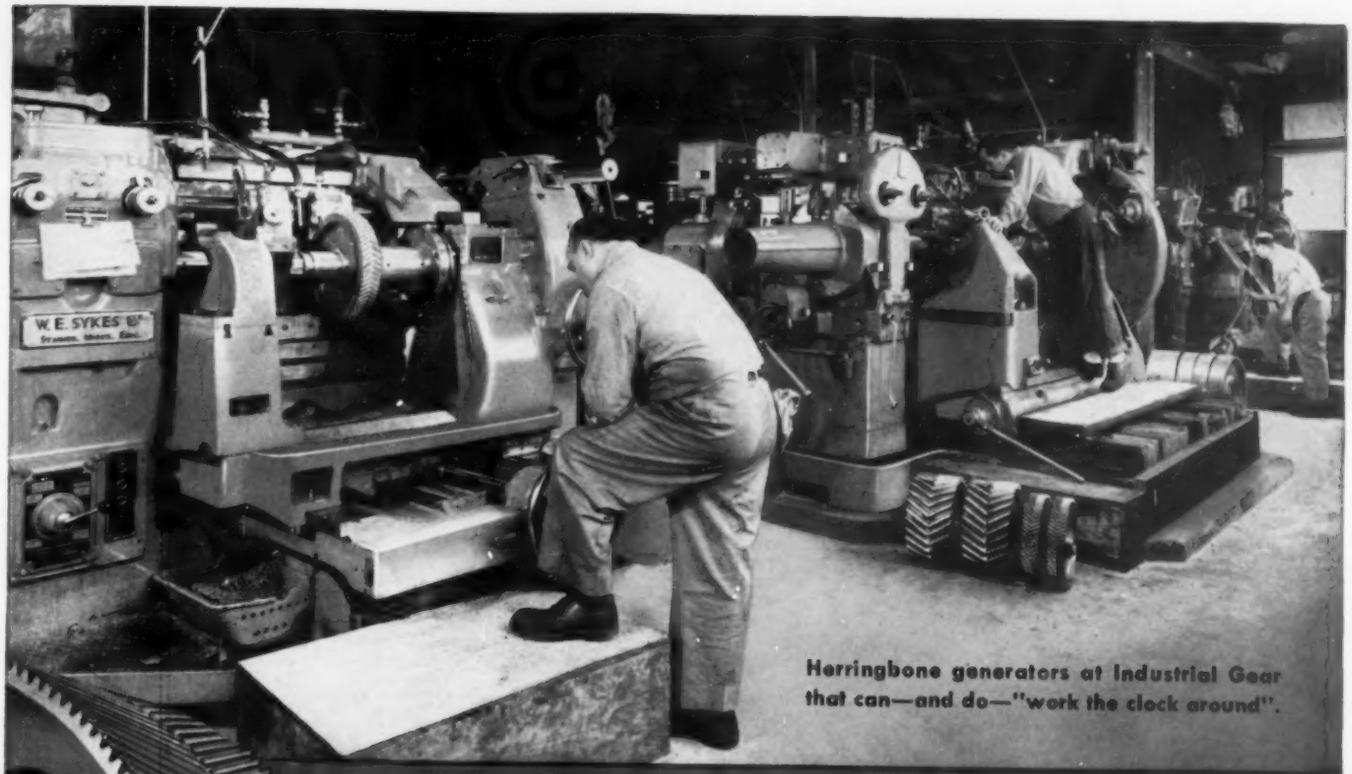
Push rod moves upward against range spring, governing ring rotation in accordance with the diagram below.


PER CENT OF RING OR PEN MOTION
HAGAN RING BALANCE RING MOTION
CORRECTED PEN MOTION REQUIRED FOR UNIFORM FLOW CHART
CONVENTIONAL RING OR FLOAT MOTION
PER CENT OF FLOW READING ON UNIFORM FLOW CHART

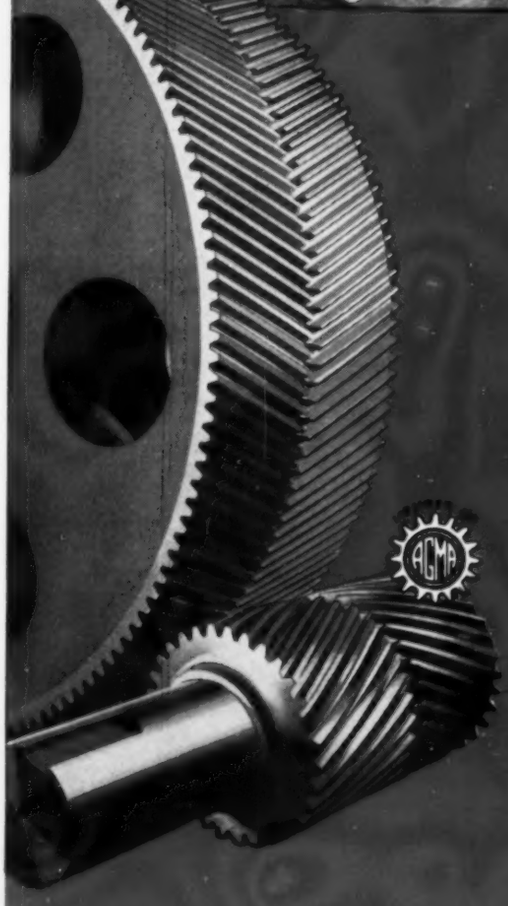
Excess motion of the Hagan ring, as shown by upper curve, is converted (with a gain in torque) into linear pen movement by a gently sloping cam.



New, rigid, weatherproof, die-cast, aluminum case. Four-piece back for complete accessibility.




Herringbone generators at Industrial Gear that can—and do—"work the clock around".



# Greater than ever . . . HERRINGBONE PRODUCTION CAPACITY!

Massive production facilities are now in operation at IG to produce one or a thousand Herringbone cut gears . . . to meet your precise specifications always on time. This battery of Herringbone generators is part of the vast production potential at Industrial Gear where every type of cut gear is produced in its own specialized department by highly trained craftsmen. Further, every IG gear is assured always, all ways "Assembly Ready."

This is another reason why IG can become your dependable Gear Department regardless of the type and quantity of gears you need . . . when you need them.

*Write for complete, FREE "Gear Packet" showing Industrial Cut Gear products, applications, and services.*

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## INDUSTRIAL GEAR MFG. CO.

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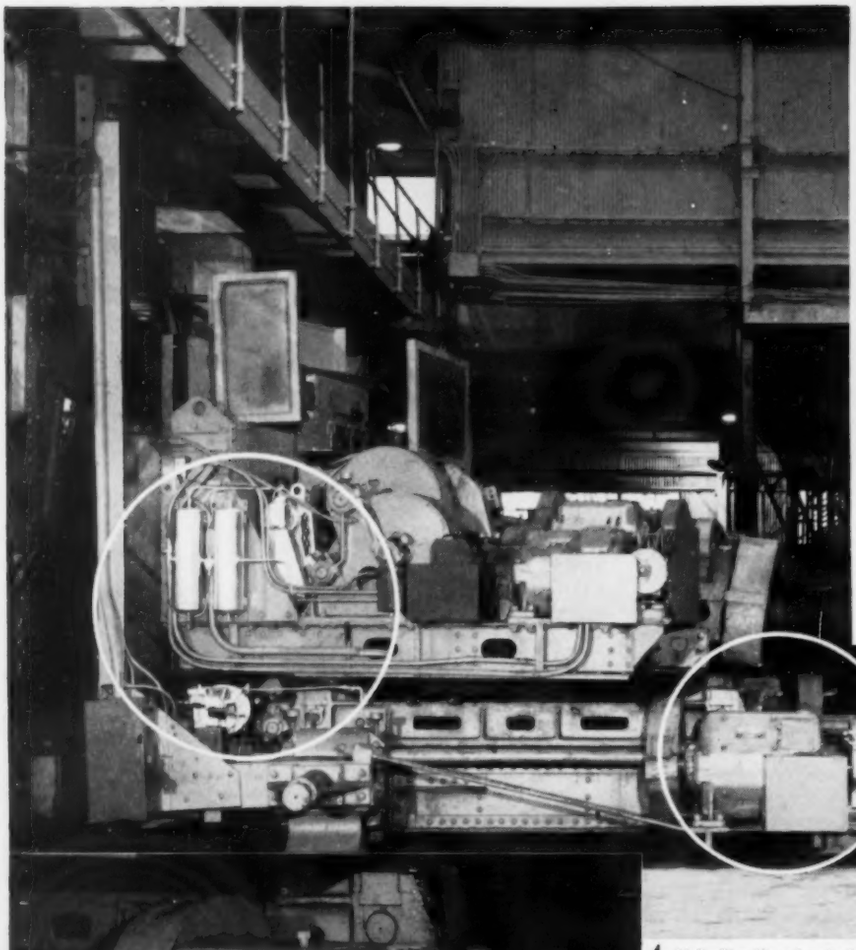
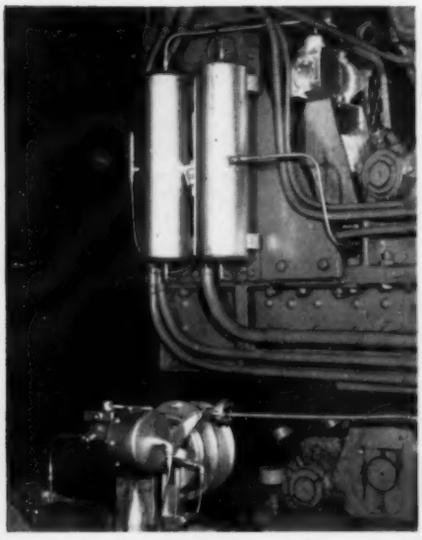
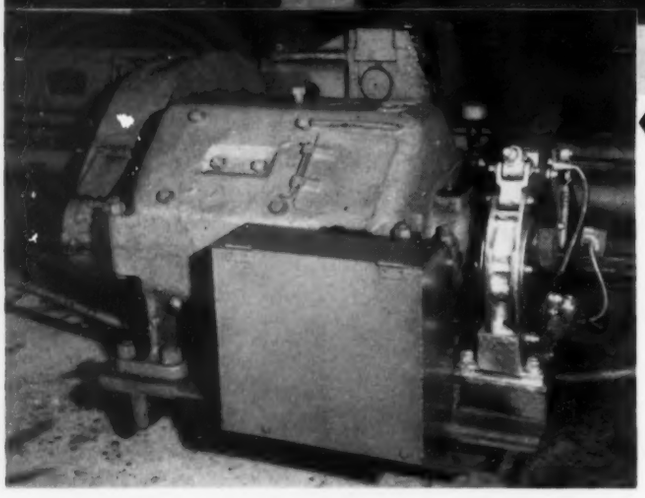




Air line and take-up reel provides controlled air pressure to the Wagner power cluster which actuates the brakes. Wagner Air Compressor and Tanks, at top of photo, supply the system with necessary air pressure service.



U.S. Steel's wheel charging car is equipped with Wagner type H Hydraulic Crane-Bridge Brakes, as shown at left.

# Wagner power brake system controls movement of wheel charging machine for U. S. Steel

This 21-ton wheel charging car at U. S. Steel Corporation, Gary, Indiana plant works at high speed to feed an automation line. It takes red hot railroad car wheels from a forging press—carefully places them in a re-heating furnace—moves them to the automated line for shaping, trueing and marking.

A Wagner Air-over-Hydraulic Industrial Power Braking System, especially designed for this application, keeps this machine under complete control. The operators can make safe, sure, precise stops with ease.

Wagner can now offer such Power Brake Systems to meet *your* requirements. Call your nearby Wagner Field Engineer—let him help you make safe, sure stops with your speeded-up charging machines.

157-1

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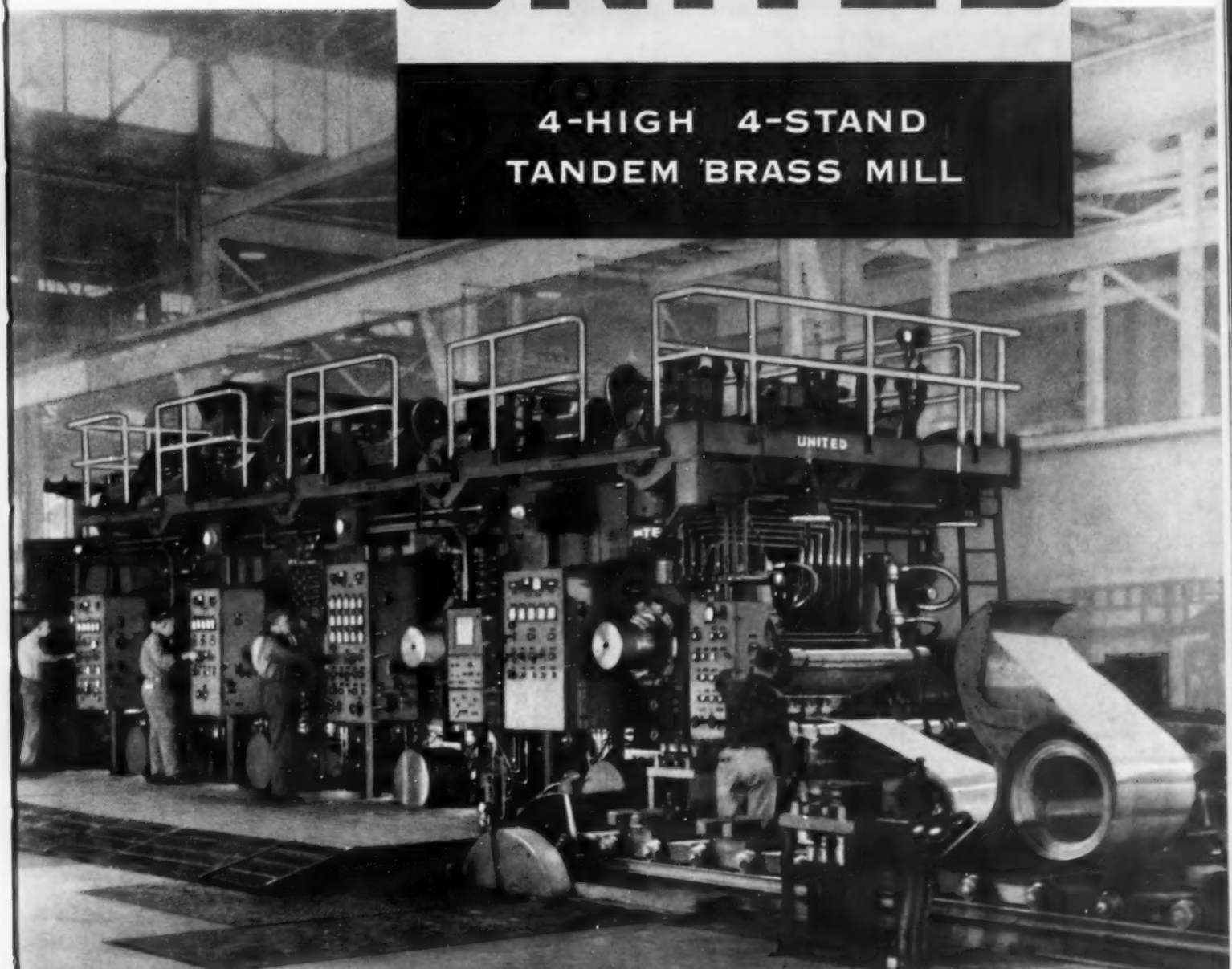
# UNITED®

## 4-HIGH 4-STAND TANDEM BRASS MILL

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*for higher performance it's*

# OHIO MAGNETS

Size for size, Ohio Magnets lift larger loads over longer periods because they *operate cooler*. So for extra magnet lifting power, extra magnet value—always specify Ohio Magnets and Ohio Magnet Controllers. There's a type and size for every lifting job. Send for free copy of Bulletin 112, or consult the Yellow Pages for Ohio offices in principal cities.

AA-1477

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Ohio Also Makes Separation Magnets • Nail Making Machines • Fractional Horsepower, Shell and Torque Motors

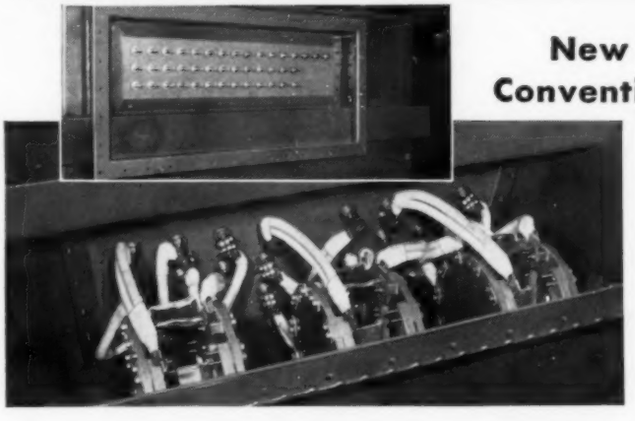
TAP-CHANGING downtime reduced from hours *to minutes!* That's the profit advantage you get with the improved tap-changing arrangement on Allis-Chalmers furnace transformers. Tap leads are brought directly to a motor-operated tap changer housed in a *separate* compartment. The ease with which taps can be changed is the secret behind the outstanding time conservation.

### Advantages of Separate Compartment Located On the Side

- Affords convenience of changing taps from floor—eliminates hazards associated with top-of-transformer work.
- Eliminates possibility of objects dropping into tank.
- Reduces height of tank by eliminating terminal board.
- Main tank need only be opened for periodic inspection.

## Furnace Transformer

# Tap Sequence Changed in Minutes!



### New Selectoheat Arrangement Eliminates Conventional Multi-Position Terminal Board

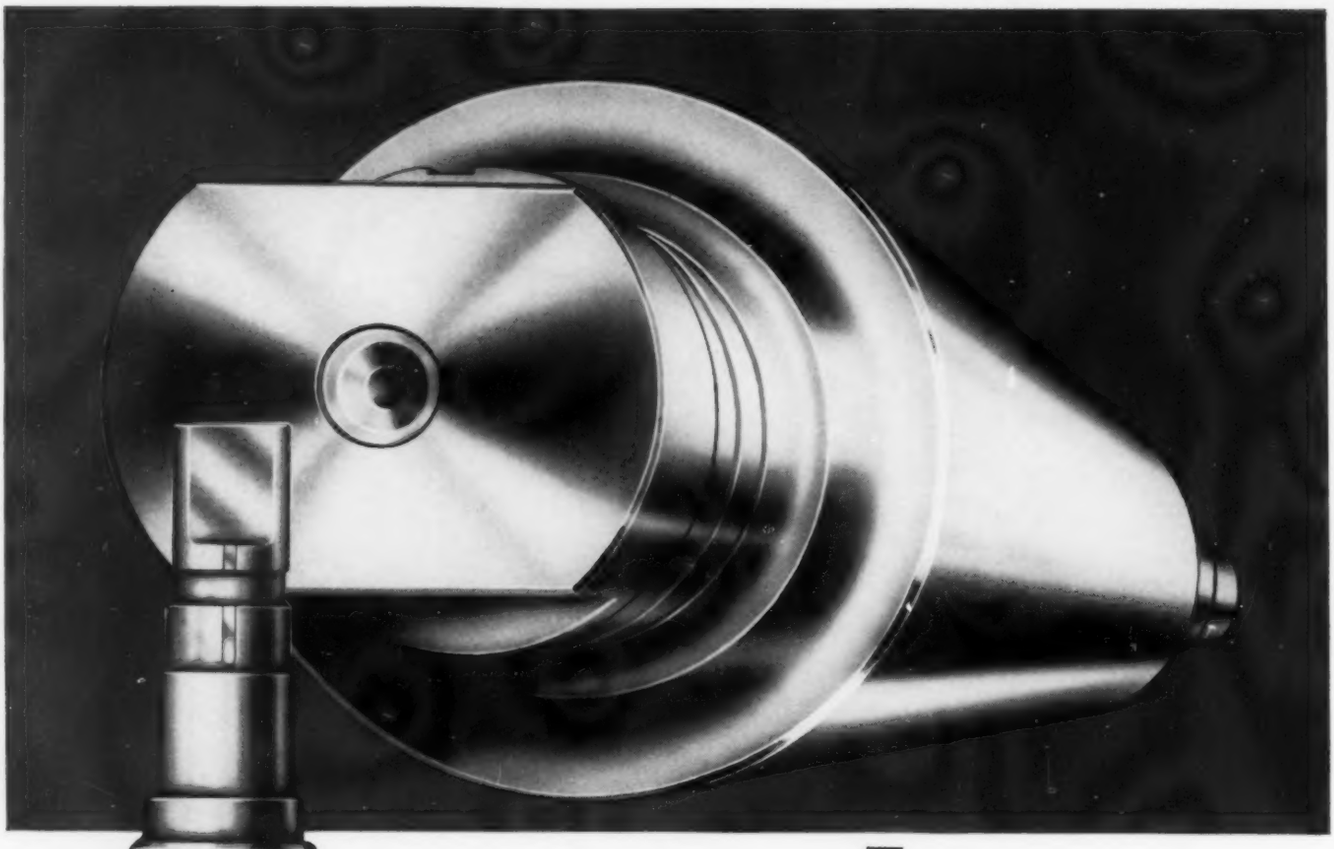
All primary taps are brought out of the main tank through a panel to the tap changer compartment. Panel completely isolates compartment from main transformer tank.

**Get all the facts.** See your A-C representatives or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

*Selectoheat* is an Allis-Chalmers trademark.

# ALLIS-CHALMERS

A-5391



# experience

*...one of the unseen extra values you get in every*

## NATIONAL ROLL

In the final analysis, the quality of a roll is determined by the experience of the maker . . . Experience in metallurgy, experience in casting, experience in heat treating and machining.

For almost fifty years, National has been making rolls for the metal industry throughout the country. And now this experience is backed by the years of metallurgical experience of National's parent organization, General Steel Castings Corporation.

Such experience is your assurance of the best in iron and steel rolls . . . rolls that will give you dependable service, higher tonnages and longer life. Try National rolls and see.

**GENERAL STEEL CASTINGS CORPORATION**

**NATIONAL ROLL & FOUNDRY DIVISION**

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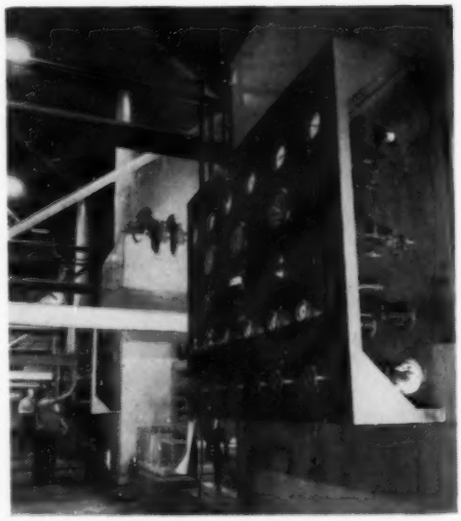
Your Key to this Plant



**an Eichleay "Turnkey" Installation**

**Air Products Inc.**

**Oxygen Plant**

**at**

**Jones & Laughlin Steel Corporation**

**PITTSBURGH WORKS**

**Eichleay**

*ESTABLISHED 1875*

**CORPORATION**

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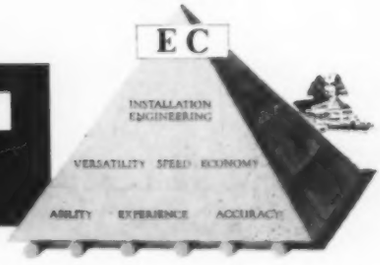


# What's the best way

**LINK-BELT conveying systems provide the answers to more production, less waste, improved safety and working conditions**

Overall efficiency involving every phase of steel production—from raw materials to finished product — is assured with Link-Belt's modern materials handling equipment. Link-Belt can supply complete conveying systems — designed to increase capacity, cut costs and reduce waste — for bulk materials, coils or any other form of steel.

Link-Belt's engineers will work with your engineers, consultants and builders of mill and process equipment to help you achieve these benefits in your mill. Just call or write your nearest Link-Belt district office.

---

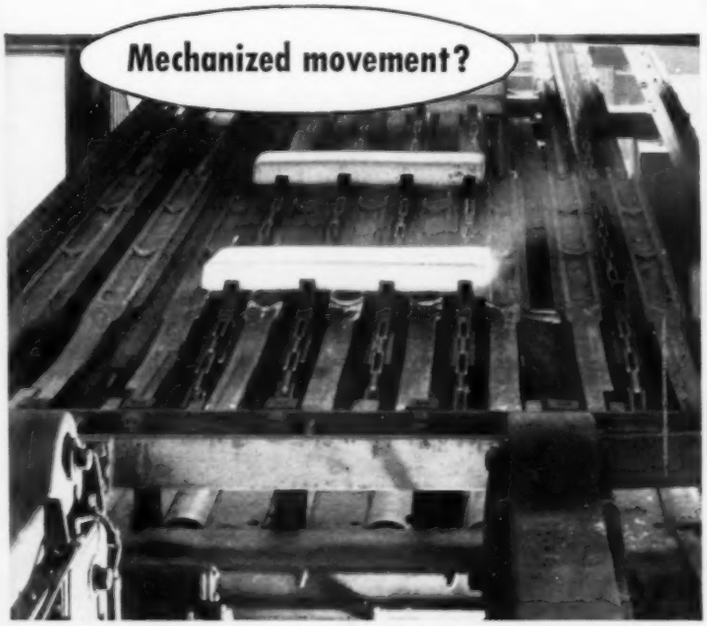
This important Detroit steel mill greatly increased its cold rolled steel capacity — with no appreciable addition in floor space — by installing three Link-Belt conveyors. Much larger coils are now handled easily with less scrap loss and less idle mill time.

# to boost your output?

## Better raw materials handling?

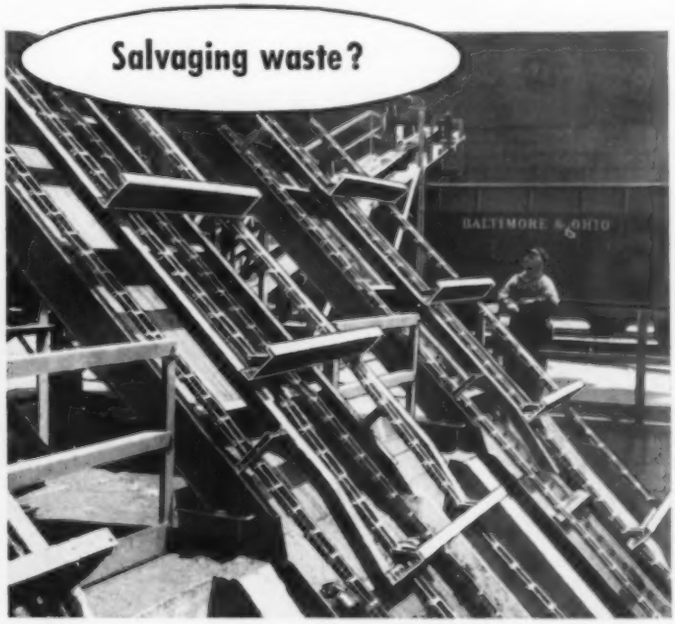
Link-Belt conveyor systems solve the problems of handling and storing various ores, coke, stone, pellets and sinter which are required by the improved techniques of burdening blast furnaces. They are designed to utilize plant space more efficiently in existing mills — fit into the new processes and are suited to the higher capacities of ship unloading and increased production. Regardless of size or physical layout of your mill, Link-Belt can provide a system ideally suited to your conditions.

## Mechanized movement?



Throughout the entire mill, Link-Belt conveyors contribute to higher efficiencies and capacities, better space utilization, lower costs and greater safety in the handling of slabs, billets, plates, coils and tubes, as well as raw materials. This conveyor employing Link-Belt steel chain transfers steel billets up incline.

## Salvaging waste?




Mill scale recovery was boosted from 250 to 475 tons a week — 72% pure iron — after Link-Belt Straightline Collectors were installed at this mill. In addition, two previous problems (clogged sewers and river pollution) were eliminated. One of five recent L-B installations of this kind.

**LINK-BELT**

**MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION MACHINERY**

93.240

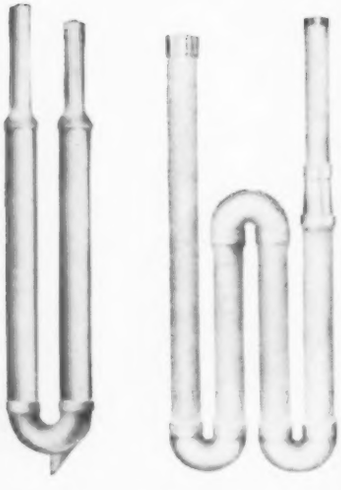
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

# THIS IS A FOUNDRY?

Looks more like a chemical lab, doesn't it? And that's exactly what it is—in the Electro-Alloys plant at Elyria. It's typical of our complete research and metallurgical facilities—which also include X-ray and physical testing laboratories.

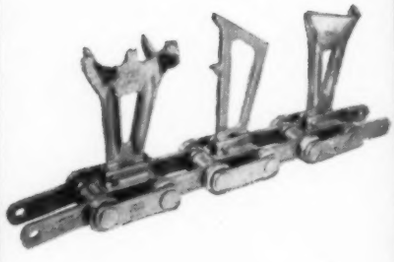
Out of research and metallurgical facilities like this has come the reputation of THERMALLOY* heat-resistant castings—for long-life economy in scores of steel mill applications. Just a few of these are shown below. Your nearby Electro-Alloys representative will be glad to give you full information about them, and many more...or assist you with any high-heat-resistant casting problem you may have. Why not call him? Electro-Alloys Division, 8068 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.



**Thermalloy Radiant Tubes**
Centrifugally cast, X-ray controlled, pressure-tested.

**Thermalloy Furnace Rolls**
...for roller-bottom furnaces.



**Thermalloy Carrier Blades and Chain**...Three types of blades, mounted on *Thermalloy* conveyor chain.

AMERICAN Brake Shoe COMPANY

**ELECTRO-ALLOYS DIVISION** Elyria, Ohio

By Melvin Nord, Patent Attorney, Detroit, Mich.

# Patent Reviews

*. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents . . . . patents reviewed cover period February 26, 1957 through March 26, 1957 . . . .*

## METHOD OF MAKING CLAD STEEL

▲ U. S. 2,782,497, issued Feb. 26, 1957 to John M. Campbell and assigned to Composite Steels, Inc., describes a continuous method of cladding steel.

As shown in Figure 1, three coils of metal strip are mounted one above the other. The strip 1 from the center coil B is the base strip which is to be clad by the strips 2 from the upper and lower coils C. The base strip may be carbon steel,

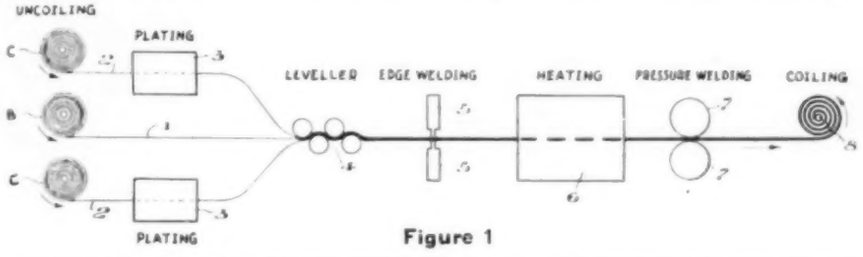



Figure 1

for example, and the cladding metal strips stainless steel. The cladding strips pass through electroplating units 3, where their inner surfaces are plated with a metal which is amenable to pressure molding, e.g., with iron.

The strips are then brought together, passed through a flattening device 4, and then passed between edge welders 5. The composite strip is then heated in a furnace 6 to a temperature which will permit the component strips to be welded together when a predetermined pressure is applied to them. This pressure is applied by a pair of rolls 7 immediately after the strip leaves the furnace. The final strip is then coiled on a reel 8.

## APPARATUS FOR SHOOTING MATERIAL INTO CUPOLAS OR BLAST FURNACES

▲ U. S. 2,784,037, issued March 5, 1957 to Alfred Rexforth, describes an apparatus for injecting metal shavings, borings, silica, lime, etc., into the melting zone of a cupola or blast furnace.

Figure 2 shows the apparatus. At the start of the operation, check-valve C is held closed by air pressure from pipe G, supplied from duct L. The air flow also prevents flame from entering the apparatus from the furnace. Valve K is closed, and the handle F of sleeve D is rotated to the position shown, to bring the opening 17 into register with the outlet of feed hopper A. This causes the chamber B to be filled from the hopper with the turnings or other scrap metal or materials it is desired to inject. The handle F is then rotated so that the slot 17 is no longer in register with the hopper outlet and the chamber B is sealed from the hopper. Valve K is opened and the blast of compressed air striking the base of the material in chamber B forces it violently up against the check-valve C. Due to the sudden application of force, and the momentary resistance of valve C, the materials are compacted to a certain extent to form a cylindrically shaped slug before the check-valve swings open to permit the charge to pass into the cupola or blast furnace. Thus the metal strikes the melting zone as a more or less compact mass. In other words, it is "shot" in. Small pieces of coke, slag or the like

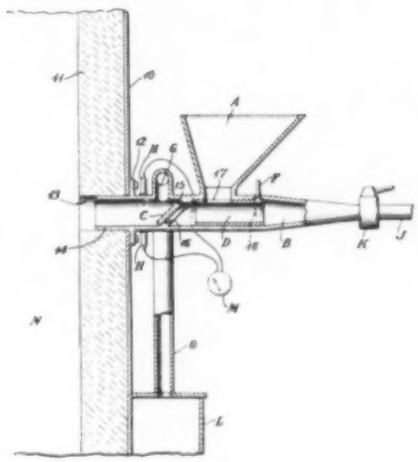


Figure 2

which might be in the mouth of the shooting canal are demolished and larger pieces are brushed aside by the rapidly moving slug, so that the injected material penetrates deep into the interior of the cupola. Upon striking the bed of material in the melting zone, the slug breaks up into lumps or pieces which penetrate deeply into the glowing coke bed. Thus, the injected charge is well distributed through the melting zone, which results in even melting and a saving of coke.

When the slug of material passes through the magnetic field set up in canal 14 by the magnet H, there is a change in the strength of the field, which can be detected by the indicating device M. From the change in the magnetic field and the duration of the charge the approximate quantity of material introduced per shot can be determined.

## POURING LADLE FOR USE IN DEGASSING OF STEEL

▲ U. S. 2,784,961, issued March 12, 1957 to Werner Coupette, Adolf

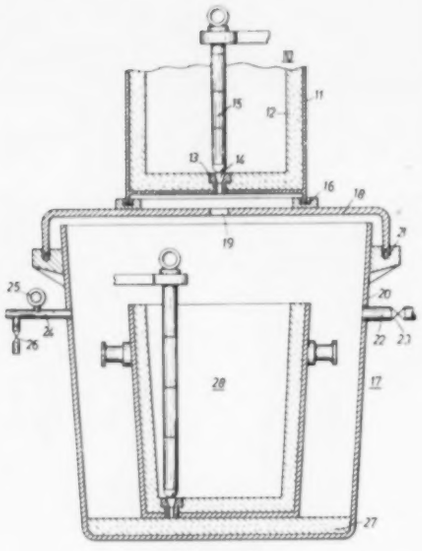


Figure 3

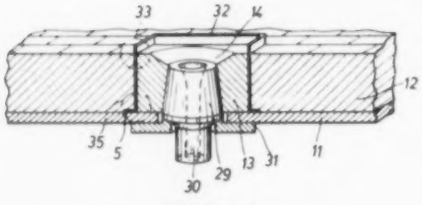


Figure 4

Sickbert and Rudolf Westib and assigned to Leybold-Hochvakuum-Anlagen, G.m.b.H., relates to the treatment of steel by degassing under vacuum. For this purpose, a vessel is used which is adapted to be evacuated. The molten metal is poured into the evacuated vessel through a hole in its lid. The pouring ladle rests on the lid of the evacuated vessel, and the seat of the pouring ladle is sealed in order to prevent air from passing into the evacuated vessel. The pouring ladle consists of an outer metal shell provided with a refractory lining. The nozzle is formed by a body of ceramic material with a central bore through it, and it is inserted into the refractory lining and projects out of the metal shell.

It has been found that during the transfer of the liquid metal, the vacuum deteriorates, in spite of a perfect seal between the bottom of the ladle and the lid of the evacuated vessel, because air passes through spaces between the metal shell and the lining of the ladle, and through the lining itself.

This difficulty is avoided by use of the present invention. Figure 3 shows the general arrangement, including ladle 10 with metal shell 11 and firebrick lining 12, ceramic material 13 and nozzle 14 at the bottom of the ladle, stopper rod 15, vacuum vessel 17, sealing rings 16 and 21, opening 19 in the lid of the vacuum vessel, and receiving ladle 28. Figure 4 shows how air leakage around firebrick, lining 12 is avoided. A ceramic nozzle 29 is inserted within the nozzle 14, and a metal shield 32 surrounds the ceramic body 13. This shield is welded at its lower rim to the metallic bottom 11 of the ladle, and extends with its upper rim into the liquid metal.

## REGENERATION OF PICKLING LIQUOR

▲ U. S. 2,785,957, issued March 19, 1957 to Othmar Ruthner, describes a process for treating waste pickle liquor for continuously recovering sulphuric acid and iron oxide.

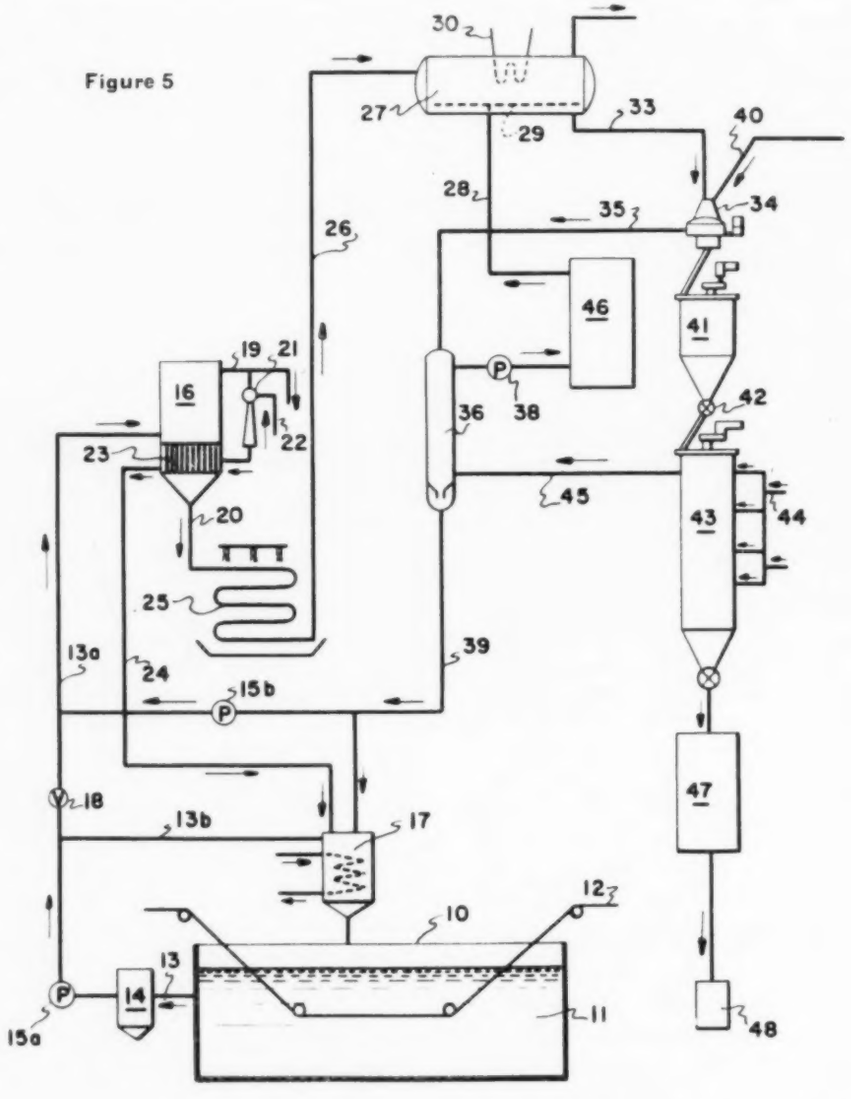
As shown in Figure 5, the system consists of a tank 10 containing a pickling bath 11 in which an iron body is submerged, such as a traveling steel strip 12. Partially spent liquor passes through filter 14 and is pumped in part to a salting-out type evaporator 16, and in part through a heating and blending tank 17 and back to the bath 11. The evaporator 16 discharges a slurry consisting of acid solution and $FeSO_4 \cdot H_2O$ through a bottom outlet 20. Recovered concentrated sulphuric acid may be recycled by pump 15b to keep the slurry pumpable. The steam chest 23 of the evaporator discharges condensed water to the heating and blending tank 17 and then into the pickling bath.

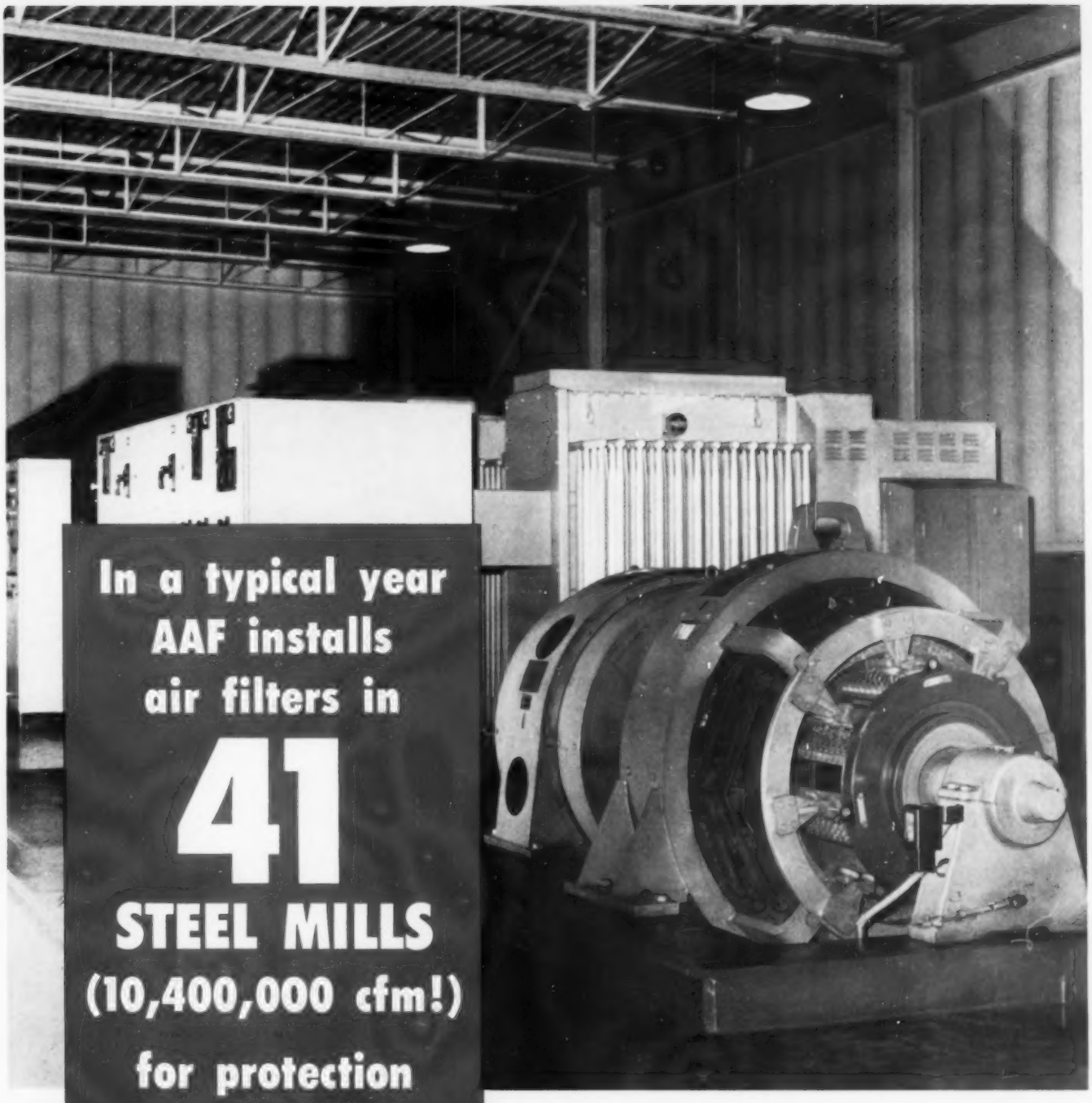
After cooling, the slurry passes to reactor tank 27. Gaseous HCl is fed in through a sparger 29, causing the reaction:

$$FeSO_4 \cdot H_2O + H_2O + 2HCl \rightarrow H_2SO_4 + FeCl_2 \cdot 2H_2O$$

Cooling coils 30 maintain a temperature of about 25 C. The $FeCl_2 \cdot 2H_2O$ is separated from the reaction

Figure 5





**In a typical year AAF installs air filters in**

# 41

**STEEL MILLS (10,400,000 cfm!) for protection of motor room equipment**

**HERE'S WHY:** instead of making one or two kinds of air filters, AAF makes *all* kinds. This assures you that, no matter what filtration conditions you face, you get the *efficiency you need* plus the *maintenance characteristics you want!* Talk over your clean air needs with your local AAF representative.

AAF herman nelson

**American Air Filter**
COMPANY, INC.

302 Central Avenue, Louisville 8, Kentucky
American Air Filter of Canada, Ltd., Montreal, P. Q.

AAF Filters and Precipitators

AAF Dust Control Equipment

**BETTER AIR IS OUR BUSINESS**

Herman Nelson Unit Heaters

Illinois Heating Specialties

*"Not once . . . but three times*

**ELLIOTT turbine-driven**

*blast furnace compressors were selected!"*

***Service Report***

The first unit operated four years and four months without shutdown. After internal inspection, the serviceman reported, "Turbine buckets, disks, shaft, labyrinth packing diaphragms, and nozzle rings in good shape. Compressor impellers in very good condition . . . no sign of erosion . . . compressor clean throughout."

***Service Report***

One of the units was opened for routine inspection after three year's service. The report—*everything fine.* All three units are rated 90,000 scfm at 30 psig air discharge. These Elliott centrifugal compressor units serve one of the nation's most prominent blast furnace plants in Ohio.

***Service Report***

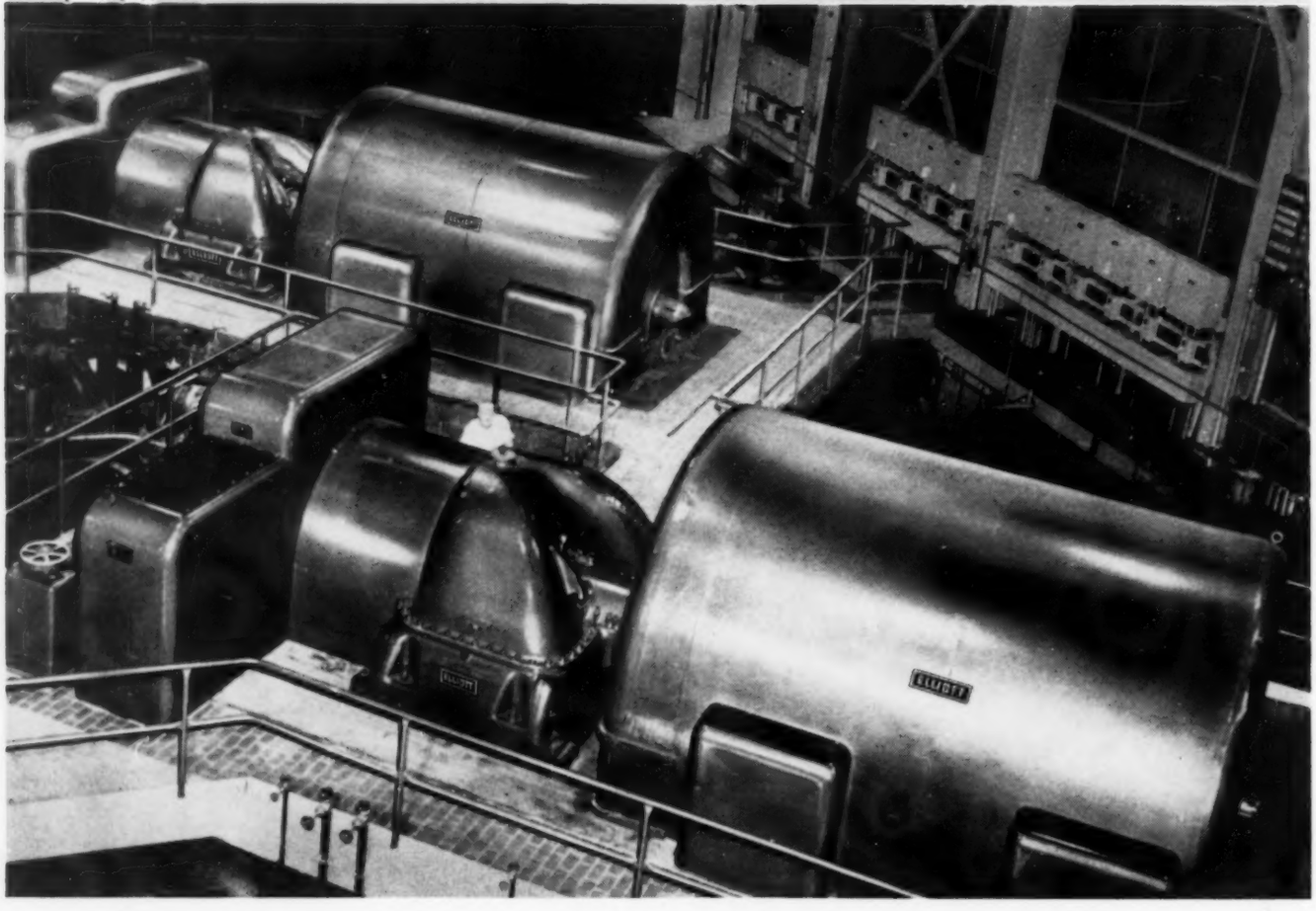
Another unit installed later duplicates the original two units seen in the photo below. This unit has operated since July, 1953—another example of Elliott's success in designing and building compressors matched to their drives to achieve maximum dependability and uniform 24-hour-a-day service.

***. . . each installation has been distinguished by long-term, non-stop performance***

**These long, uninterrupted runs are made possible by Elliott's *all-welded impellers.* The superior performance of Elliott welded impellers has been proven by many years of experience in steel mills all over the country. What's more, Elliott blast furnace compressors are designed to match the Elliott turbine drives . . . providing a unit streamlined in appearance and capable of long, trouble-free performance. Elliott multistage compressors are available with inlet capacities up to approximately 150,000 cfm. For details, write Elliott Company, Compressor Department, Jeannette, Pa.**

**ELLIOTT Company**

P7-5



product by a centrifuge 34. The liquid sulphuric acid filtrate is sent to a degassing tower 36, to remove HCl, which is recycled to the reactor tank 27. The heating medium for the degasser 36 is the hot gas from a roaster 43. In the roaster, the $FeCl_2 \cdot 2H_2O$ is converted to iron oxide and HCl. The HCl is contained in the hot furnace gases which go the degasser 36.

In U. S. 2,785,999 (same date, same inventor), a modification of this process is provided. The pickling medium consists of liquid sulphuric acid and gaseous HCl. The pickle liquor is supersaturated with HCl to precipitate $FeCl_2$ crystals. The crytals are separated from the pickling acid and roasted, to form iron oxide and HCl.

### REDUCTION OF IRON ORES BY CARBON AND STEAM

▲ U. S. 2,786,747, issued March 26, 1957 to Hans Gallusser and assigned to Ateliers des Charmilles S.A., describes a process and apparatus for reducing iron ores by carbon and steam.

The decomposition of carbon by steam at 950 C takes place according to the equation:

$$C + H_2O \rightarrow CO + H_2 - 27.9 \text{ Kcal} \quad (1)$$

At this temperature, very little $CO_2$ is formed. The two gases CO and $H_2$ are good reducing agents, and may be used to reduce iron ore at 950 C as follows:

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2 + 6 \text{ Kcal} \quad (2)$$

$$Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O - 26.6 \text{ Kcal} \quad (3)$$

Equation (3) forms enough $H_2O$ for use in equation (1) to form the 3CO and $3H_2$ required in equations (2) and (3). Some additional steam must in practice, however, be added. Since all three reactions are operable at the same temperature, 950 C, they can all be carried out in the same furnace, provided heat is furnished. This is furnished in the present invention by electric induction heating in a shaft furnace.

### METHOD OF MELTING IRON AND STEEL

▲ U. S. 2,786,748, issued March 26, 1957 to Carl George de Laval, Jr., describes a method of rapidly melting iron or steel in a reverberatory furnace.

In the usual practice, the iron-containing material is first melted to form a molten pool in the bottom of the furnace, and then the carbon content is reduced to the desired level by the addition of iron ore or mill scale. This requires that the metal be retained in the furnace for an extended period of time while the oxidation takes place.

In the present invention, the charge is melted down by alternately introducing a burning mixture of fuel and air, and then air, and repeating the cycle until the charge is melted. No mill scale is needed and the melt-down time is materially reduced, thus effecting economies in furnace time and fuel costs.

### PRODUCTION OF STEEL USING AN OPEN HEARTH FURNACE AND A CUPOLA

▲ U. S. 2,786,749, issued March 26, 1957 to Siegfried Tunder and assigned to Gesellschaft fur Huttenwerksanlagen m.b.H., describes a method of producing steel in the open-hearth furnace using metal premelted in a cupola.

The essential features of the method are the production of a very hot cupola-furnace premelted iron of low manganese, silicon and sulphur content in a hot-blast operated neutral- or basic-lined cupola furnace, and the charging of this metal after the solid charge of the open-hearth furnace is heated up and initially melted.

A surprisingly rapid and extensive combustion of the carbon is brought about and the charge runs in with a lower carbon content than is otherwise the case. The slag is also made to foam vigorously by the violent reaction and hence the dephosphorization of the charge is accelerated.

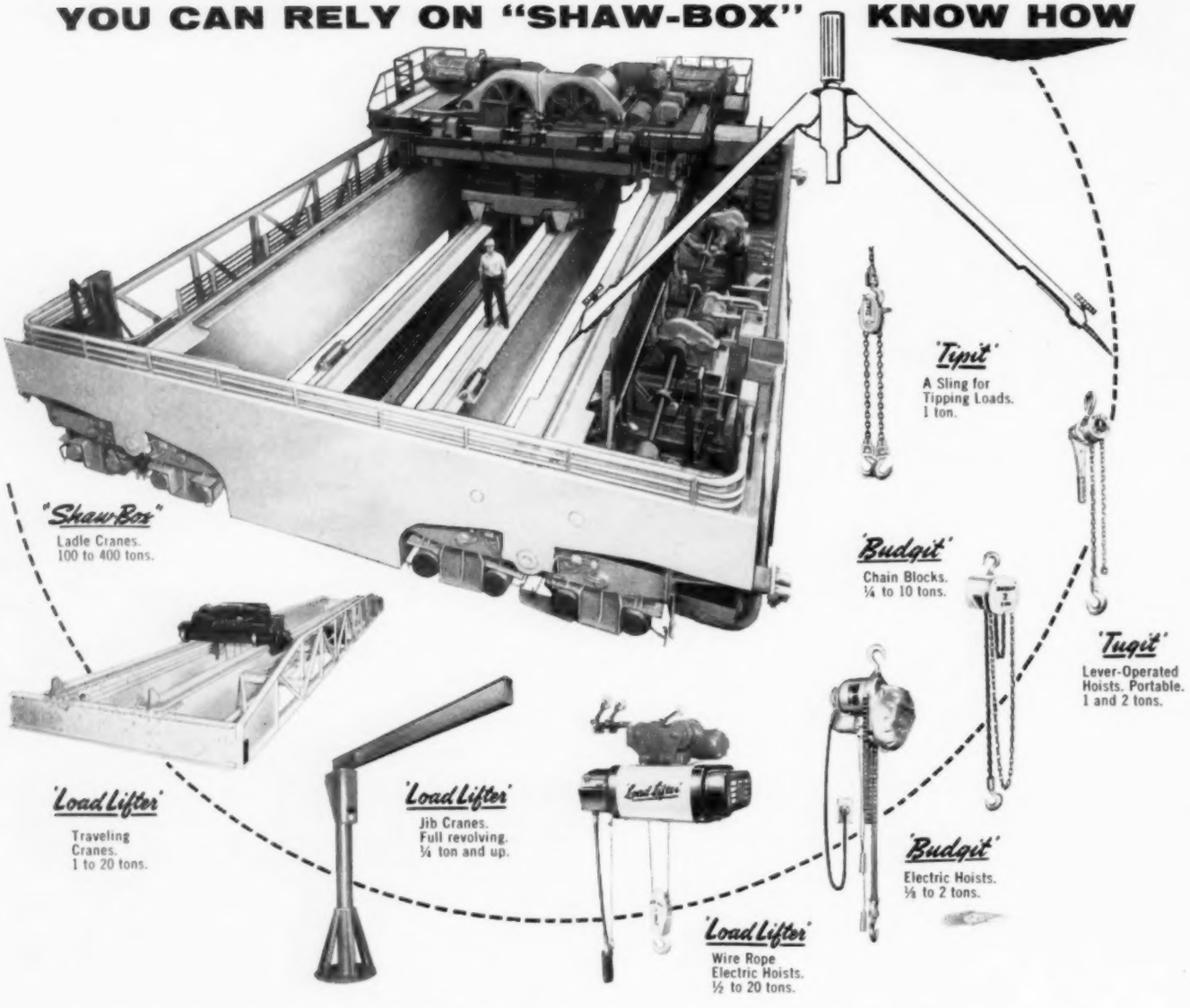
A considerable increase in output of the open-hearth furnace is achieved.

### OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

| Patent No. | Date | Subject | Inventor or Assignee |
|---|---|---|---|
| 2,782,451 | 2/26/57 | Apparatus for cleaning seam edges for welding | United States Steel Corp. |
| 2,782,478 | 2/26/57 | Sectional hot top | United States Steel Corp. |
| 2,782,516 | 2/26/57 | Apparatus for measuring the length of steel wire, strip, etc. | United States Steel Corp. |
| 2,782,662 | 2/26/57 | Lubricating means for a rolling mill | Samuel Osborn & Co. Ltd. |
| 2,783,169 | 2/26/57 | Producing nitrogen-rich wrought austenitic alloys | Ford Motor Co. |
| 2,783,288 | 2/26/57 | Electric slag resistance furnace | Vincenzo Acquarone |
| 2,783,987 | 3/5/57 | Super-hearth construction for heat treatment furnaces | C. I. Hayes, Inc. |
| 2,783,990 | 3/5/57 | Tilting melting furnace | Richard Trepmacher and Karl Leupold |
| 2,784,073 | 3/5/57 | Prevention of separation and dust formation in iron powder | Easton Metal Powder Co., Inc. |
| 2,784,074 | 3/5/57 | Method of treating iron ores containing chromium | Yawata Iron & Steel Co., Ltd. |
| 2,784,077-9 | 3/5/57 | Smelting finely divided ores | William E. Greenawalt |
| 2,784,083 | 3/5/57 | Stainless steel castings | Armco Steel Corp. |
| 2,784,125 | 3/5/57 | Wrought stainless steel | Armco Steel Corp. |
| 2,784,243 | 3/5/57 | Heat treating furnace | Pacific Scientific Co. |
| 2,784,620 | 3/12/57 | Rolling mill | Mesta Machine Co. |
| 2,784,849 | 3/12/57 | Coke oven doors and door handling machines | John M. Gillott |
| 2,784,957 | 3/12/57 | Combination coil supporting and covering apparatus for box annealing furnace | United States Steel Corp. |
| 2,784,960 | 3/12/57 | Reduction of metallic sulphide ores | Lee Foundation for Nutritional Research |
| 2,785,050 | 3/12/57 | Two-step fluid-suspension roasting of iron sulphide ore | Allied Chemical & Dye Corp. |
| 2,785,214 | 3/12/57 | Induction melting furnace | The General Engineering Co. Ltd. |
| 2,785,879 | 3/19/57 | Wet gas washing apparatus | George B. Cramp |
| 2,785,991 | 3/19/57 | Preparation of red oxide of iron | C. K. Williams & Co. |
| 2,786,266 | 3/26/57 | Method of clad fabrication | Lukens Steel Co. |
| 2,786,638 | 3/26/57 | Automatic strip coiler | Armco Steel Corp. |
| 2,786,639 | 3/26/57 | Wire winding and stripping mechanism | Continental Steel Corp. |
| 2,786,665 | 3/26/57 | Apparatus for smelting ores with liquid or gaseous fuels | Oscar F. Swenson |
| 2,786,806 | 3/26/57 | Coke oven with independent heating flue structures | Pierre E. H. Forsans |

# FOR GIANT CRANE OR SMALL HOIST

## YOU CAN RELY ON "SHAW-BOX" KNOW HOW




Steel production and processing demand overhead load-handling equipment of many types and capacities. Whether it is a crane to handle molten steel or finished products, or a hoist to facilitate shipments or plant maintenance, complete dependability and highest performance are essential.

Mills everywhere have long benefited from "Shaw-Box" research, engineering and production facilities. The same kind of professional know-how that interprets crane requirements to AISE Specifications No. 6 or your own is engineered into all products bearing our brand names. You are assured of precision craftsmanship, top efficiency and economical service from our smallest hoists as well as our huge multi-motored cranes.

If you want to equip your mill with a new soaking pit carriage, a crane of any type or capacity or hoists for any purpose, your inquiry is invited.

## "Shaw-Box" ® CRANES

57K-3

MANNING MAXWELL & MOORE INC. TRADE MARK

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SHAW-BOX CRANE & HOIST DIVISION

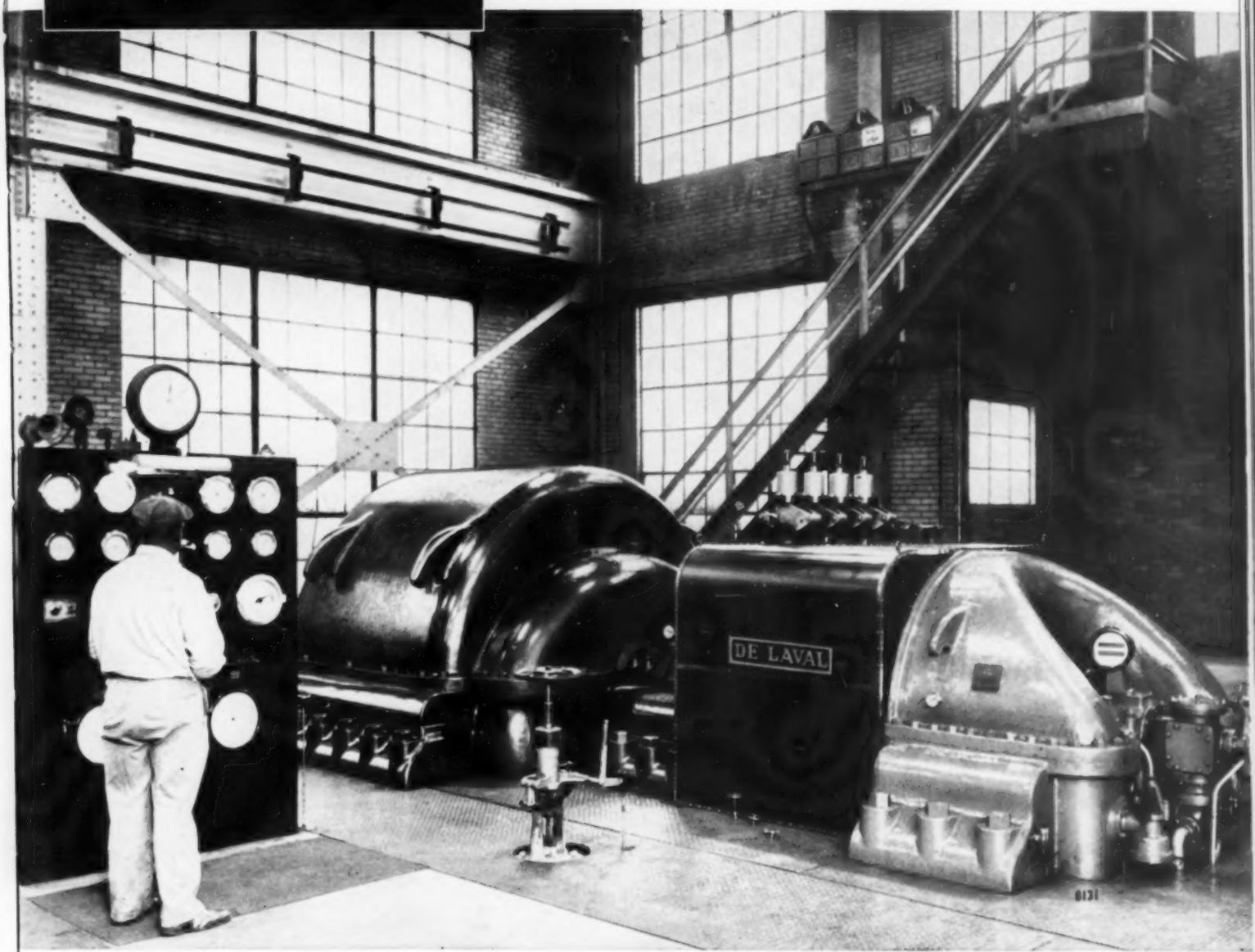
388 West Broadway • Muskegon, Michigan

Builders of "SHAW-BOX" and 'LOAD LIFTER' Cranes, 'BUDGIT' and 'LOAD LIFTER' Hoists and other lifting specialties. Other Divisions produce 'ASHCROFT' Gauges, 'HANCOCK' Valves, 'CONSOLIDATED' Safety and Relief Valves, 'AMERICAN' and 'AMERICAN-MICROSEN' Industrial Instruments, and Aircraft Products.

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Avenue Road, Galt, Ontario*

# DE LAVAL
## BLAST FURNACE BLOWERS

# *give 20 years of service at Great Lakes Steel Corp.*




Shown is one of two De Laval centrifugal blast furnace blowers at the Ecorse, Michigan, plant of the Great Lakes Steel Corporation, Division of National Steel Corporation. This 85,000 cfm unit was installed twenty years ago; another 75,000 cfm unit went on the line a year earlier. Both have given dependable round-the-clock service ever since. These turbine-driven blowers are hooked up to a multi-head which enables either one to be used in conjunction with any of the three blast furnaces.

De Laval centrifugal blowers are built in single and multi-stage types to supply air in volumes up to 150,000 cfm for all classes of service in steel, gas and coke plants. The wealth of application experience acquired by De Laval over the years assures a correct and economical solution to your blower problem.

*Send for Bulletin 0504*

**DE LAVAL** *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY

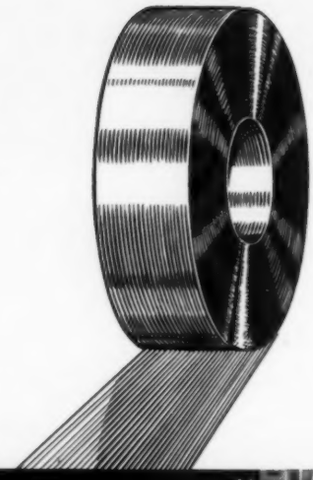
*870 Nottingham Way, Trenton 2, New Jersey*

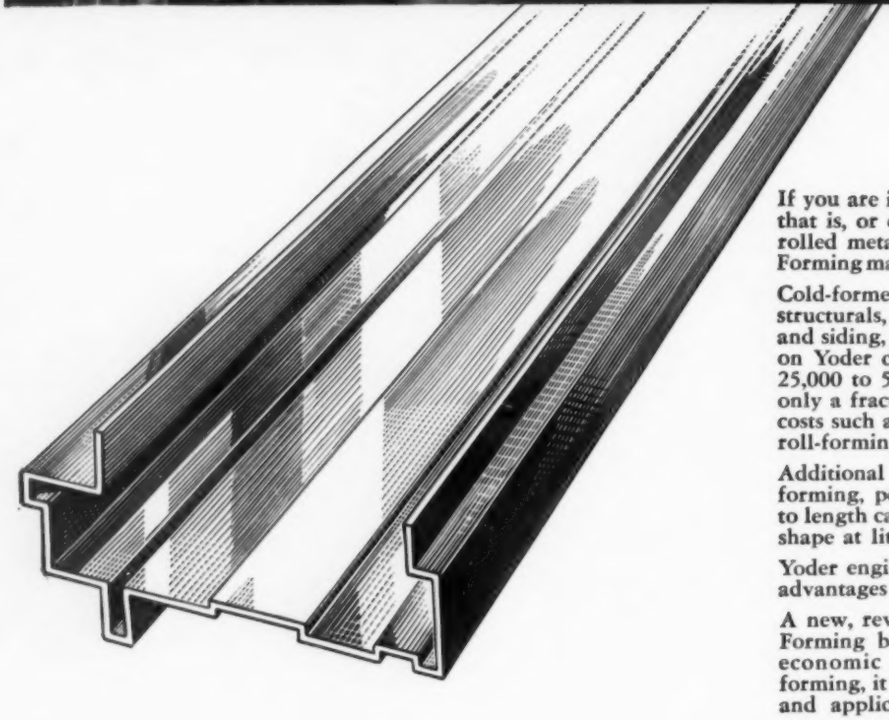
## *From Cold Strip to Finished Shapes*

# *IN SECONDS*

## *with a YODER*

# *ROLL-FORMING MACHINE*





If you are in the business of manufacturing a product that is, or could be, made wholly or partly from flat rolled metals in thicknesses up to ½", a Yoder Roll-Forming machine can help reduce your production costs.

Cold-formed shapes of every description—including structurals, tubular products, moldings, trim, roofing and siding, panels, cabinet shells, etc., can be produced on Yoder cold-roll forming equipment at the rate of 25,000 to 50,000 feet per day at a conversion cost of only a fraction of a penny per foot! With speeds and costs such as this, even part-time operation of a Yoder roll-forming line is a profitable investment!

Additional operations such as welding, coiling, ring forming, perforating, notching, embossing or cutting to length can be simultaneously introduced to the basic shape at little or no additional labor cost.

Yoder engineers are at your service in explaining the advantages of roll-forming for your individual needs.

A new, revised, Fifth Edition of the Yoder Cold-Roll Forming book is just off the press. In addition to economic and mechanical possibilities of cold-roll forming, it contains numerous illustrations of end uses and applications of roll-formed shapes. Write for your copy today.

**THE YODER COMPANY**
**5495 Walworth Avenue • Cleveland 2, Ohio**

ENGINEERING **YODER** MANUFACTURING

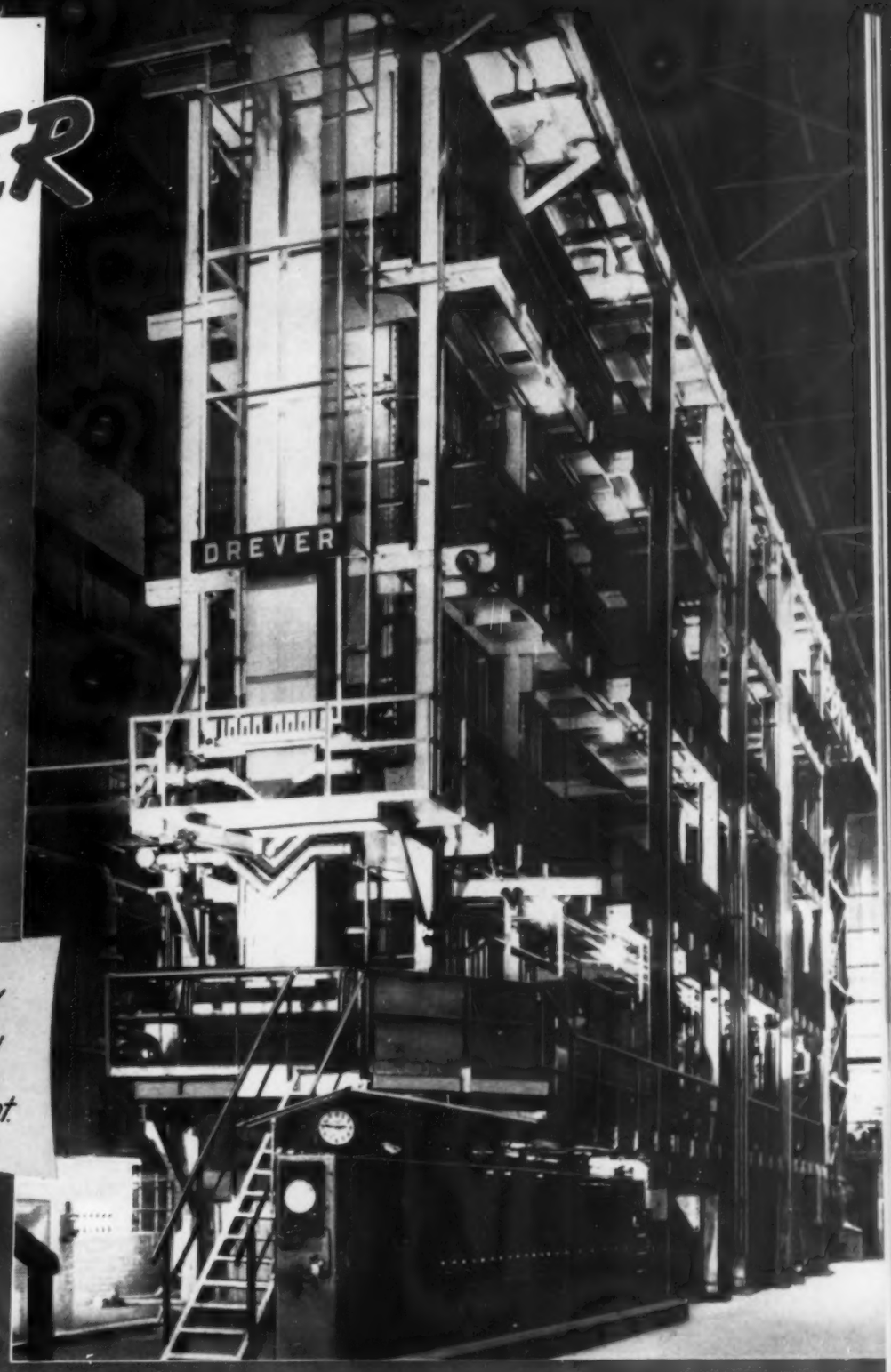
**COLD ROLL FORMING MACHINES**

**PIPE AND TUBE MILLS (ferrous or non-ferrous)**

**ROTARY SLITTING LINES**

# DREVER

## *Continuous* STRIP ANNEALING FURNACE LINE




*Delivery end of furnace for low carbon tin plate strip installed in a large Canadian steel plant.*

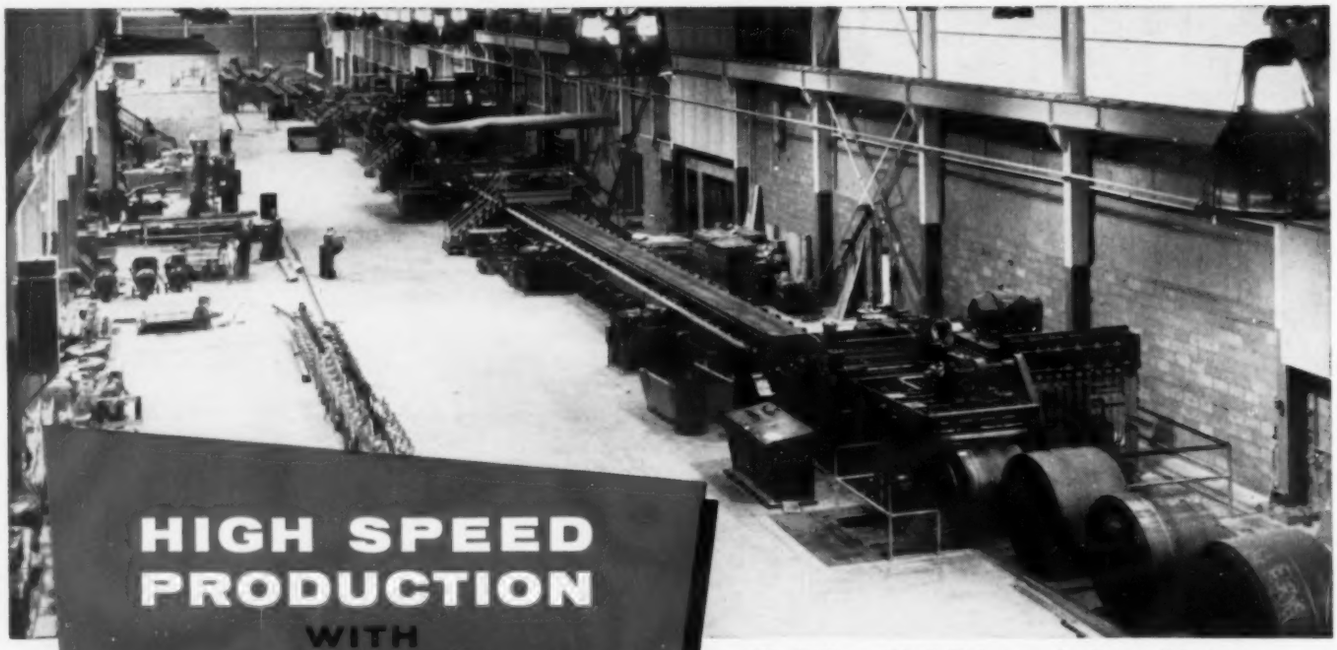
**This furnace has an installed electrical input in heating and soaking zones of 3000 KW for a rated production of 37,000 lbs/hour on .0099″ x 33″ wide strip running at 550 FPM.**

**Furnace equipment is designed to handle strip in thicknesses from .0075″ to .020″ in widths varying from 19″ to 38″.**

**HNX atmosphere gas is used to purge the furnace.**

DREVER COMPANY

..... RED LION ROAD and PHILMONT AVE., BETHAYRES, PA.



# HIGH SPEED PRODUCTION WITH RELIANCE V★S DRIVES

Six Reliance V★S Drives make it possible to operate this complete line as if it were a single machine.

Carloads of pipe are pouring out of the new Edmonton, Alberta plant of Alberta Phoenix Tube & Pipe, Ltd. This $6.5 million installation is producing pipe at unprecedented rates.

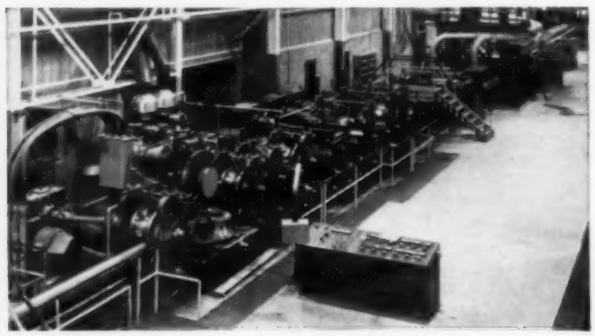
Volume pipe production requires something special in a drive system—one that furnishes precise speed control and instantaneous motor response. A wide stepless range of speeds is provided to handle various pipe diameters and lengths, and all sections of the line operate at the same relative speed.

A team of Reliance Application Engineers, working with the machinery builder, built this specialized drive. This team knows the processes of the steel industry and how to handle the problems involved. Engineering knowledge, backed by the quality of Reliance products, supplied this accurate, simple-to-operate, economical drive.

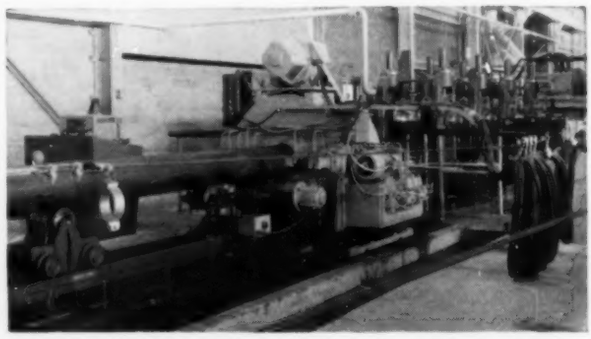
The Reliance Application Engineering Department builds drives for every industry. A team of engineers who are experts on your industry's operation, stand ready to engineer and build the drive for your particular needs.

If you would like more information on this installation, write for Bulletin L-2505.

L-1541



The welding section operator controls the speed of the entire line from this Reliance Pendent Station.



The Reliance V★S Drive on this flying cutoff automatically measures the pipe and controls the movement and speed of the carriage.

**RELIANCE ELECTRIC AND ENGINEERING CO.**

**DEPT. 118A, CLEVELAND 17, OHIO • CANDIAN DIVISION: WELLAND, ONTARIO**

**Sales Offices and Distributors in Principal Cities**

# Taylor Zircon Prolongs Ladle Life...

## produces cleaner metal too

Taylor Zircon No. 717 Ramming Mix is a most effective lining for ladles handling various types of iron and steel. A St. Louis foundry uses No. 717 exclusively for receiving and pouring ladles in their stainless steel and high alloy operations. They call it the best lining material they have ever used, because:

**cleaner metal is produced**

**ladle life is prolonged**

**less slag build-up**

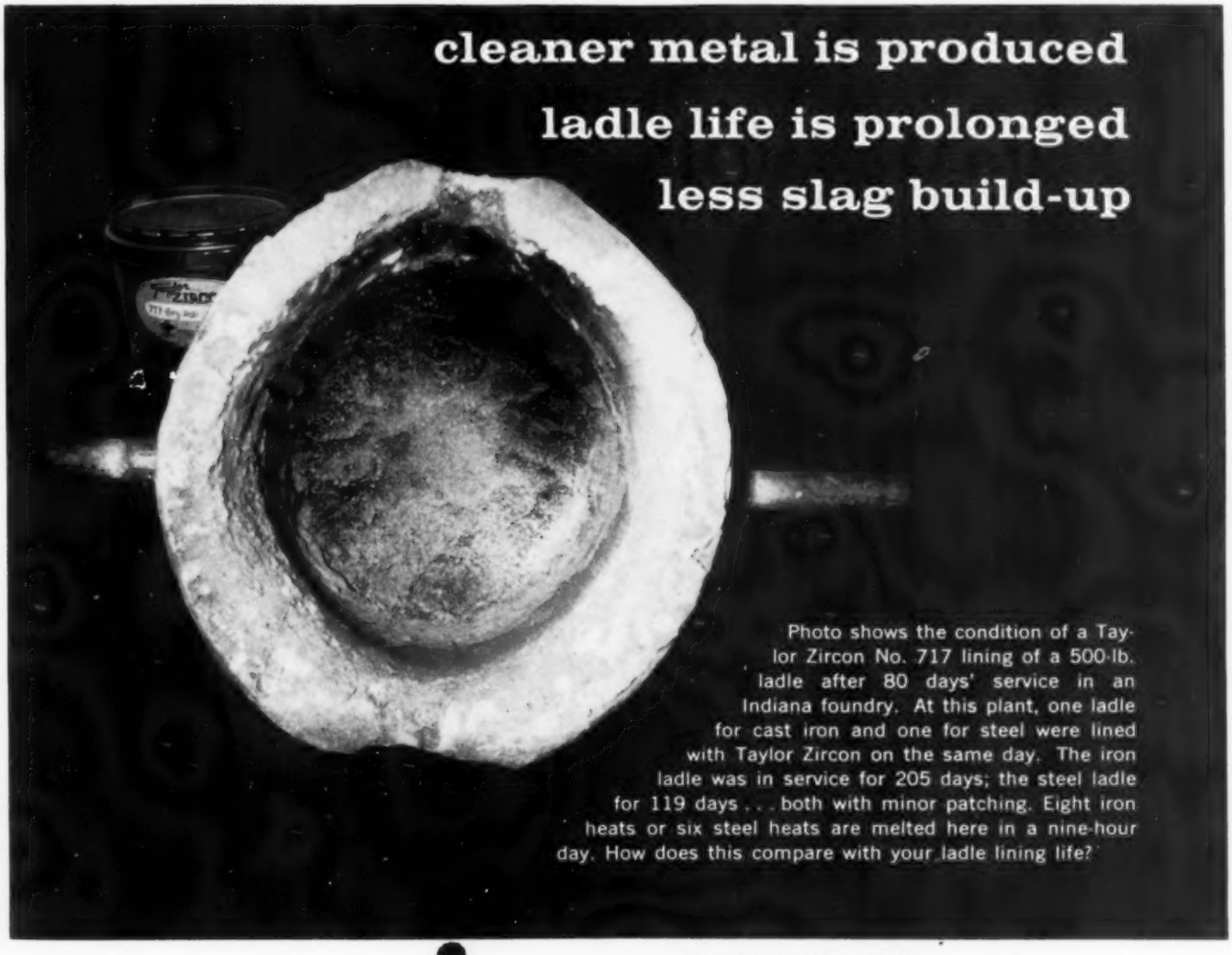


Photo shows the condition of a Taylor Zircon No. 717 lining of a 500-lb. ladle after 80 days' service in an Indiana foundry. At this plant, one ladle for cast iron and one for steel were lined with Taylor Zircon on the same day. The iron ladle was in service for 205 days; the steel ladle for 119 days . . . both with minor patching. Eight iron heats or six steel heats are melted here in a nine-hour day. How does this compare with your ladle lining life?

Exclusive Agents in Canada:
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The CHAS. TAYLOR SONS Co.
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# HOW IMPORTANT IS

# HIGH CONDUCTIVITY

# IN BLAST FURNACE COPPER?

100% thermal conductivity requires the purest copper. But it's expensive, and usually too soft to endure the abrasion of the burden.

There are techniques we know that will keep conductivity high and still give you tuyeres and plates with good wear resistance.

Techniques in the deoxidization of molten copper, for one!

Casting techniques for another. By applying ingenuity in casting, it is possible to minimize alloy content and still get the hardness you need, without adversely affecting conductivity.

So, next time you talk about thermal conductivity above 90%, remember that it takes more than pure copper to make it practical. It takes superior metallurgical skill and foundry practice.

National Bearing leads the industry in just that skill and practice. We *guarantee* conductivity above 90% when specified by the customer.

It's all a matter of what importance you assign to *high conductivity* in your blast furnace copper. And how much you think it's worth.

*Talk to us about it.*

**NBD maintains more than 500 tuyere patterns, including Wier, heavy-nose and angle-flow tuyeres, at Meadville, Pa.**

AMERICAN Brake Shoe COMPANY

**NATIONAL BEARING DIVISION**

4930 Manchester Avenue • St. Louis 10, Missouri

PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

**This NBD instrument measures thermal conductivity, using eddy currents and radio waves. It is used on test plugs at the furnace, and again on finished castings.**

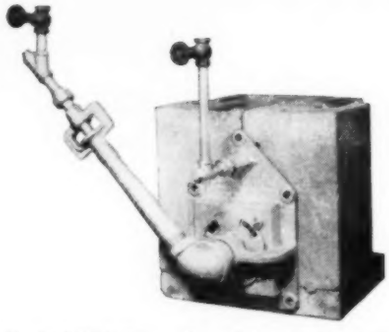
**NBD machines butts of all tuyeres to assure perfect fit.**

# When you want to put the heat on...

■ When you want to put the heat on—use the F.E.I. direct fired burner system. Any cover type annealing furnace performs faster and more efficiently with this patented direct firing system than with radiant tube firing. You can eliminate bothersome, costly tube replacement . . . get greater heating efficiency . . . faster heat-up and eliminate expensive "downtime" interruptions by putting heat *directly* inside the furnace—where it does the most good!

Use the F.E.I. direct firing burner system on your new annealing furnaces or convert present furnaces to this highly efficient system. Nearly 200 cover type annealing furnaces have already been converted to the F.E.I. direct fired system.

Contact an F.E.I. furnace specialist—today!



Typical F.E.I. Burner Assembly—the heart of any direct fired furnace. It is sturdy, automatically controlled and efficient to operate.

FURNACE ENGINEERS—designers and rebuilders of direct fired furnaces.

- Cover Type Annealing Furnaces
- Car Type Annealing Furnaces
- Galvanizing Settings
- Patenting Furnaces
- Regenerative Soaking Pits

## *F.E.I. Under New Management*

**Furnace Engineers is now under the management of Mr. A. A. Straub and his associates. All patents, engineering information and key personnel will remain with the firm. Financial management and sales policies have been modernized in line with present day business standards.**

**Furnace Engineers, Inc.**

**214 BOULEVARD OF THE ALLIES • PITTSBURGH 16, PA.**

*Write For This Descriptive Bulletin—*

80-inch continuous hot strip mill

# BLAW-KNOX CONTINUOUS HOT STRIP MILLS

Blaw-Knox designs and builds a full range of continuous, semi-continuous, and single stand reversing hot strip mills. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations including all auxiliary equipment for ferrous and non-ferrous metals, iron, alloy iron and steel rolls, Medart cold finishing equipment, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings.

BLAW-KNOX

## BLAW-KNOX COMPANY

*Foundry and Mill Machinery Division*
*Blaw-Knox Building · 300 Sixth Avenue*
*Pittsburgh 22, Pennsylvania*

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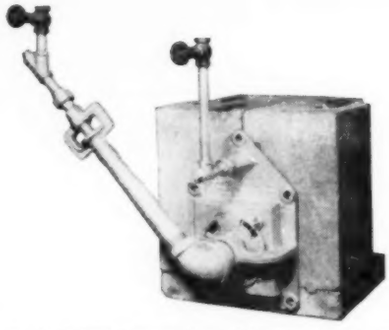

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- Cover Type Annealing Furnaces
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**214 BOULEVARD OF THE ALLIES • PITTSBURGH 16, PA.**

*Write For This Descriptive Bulletin—*

80-inch continuous hot strip mill

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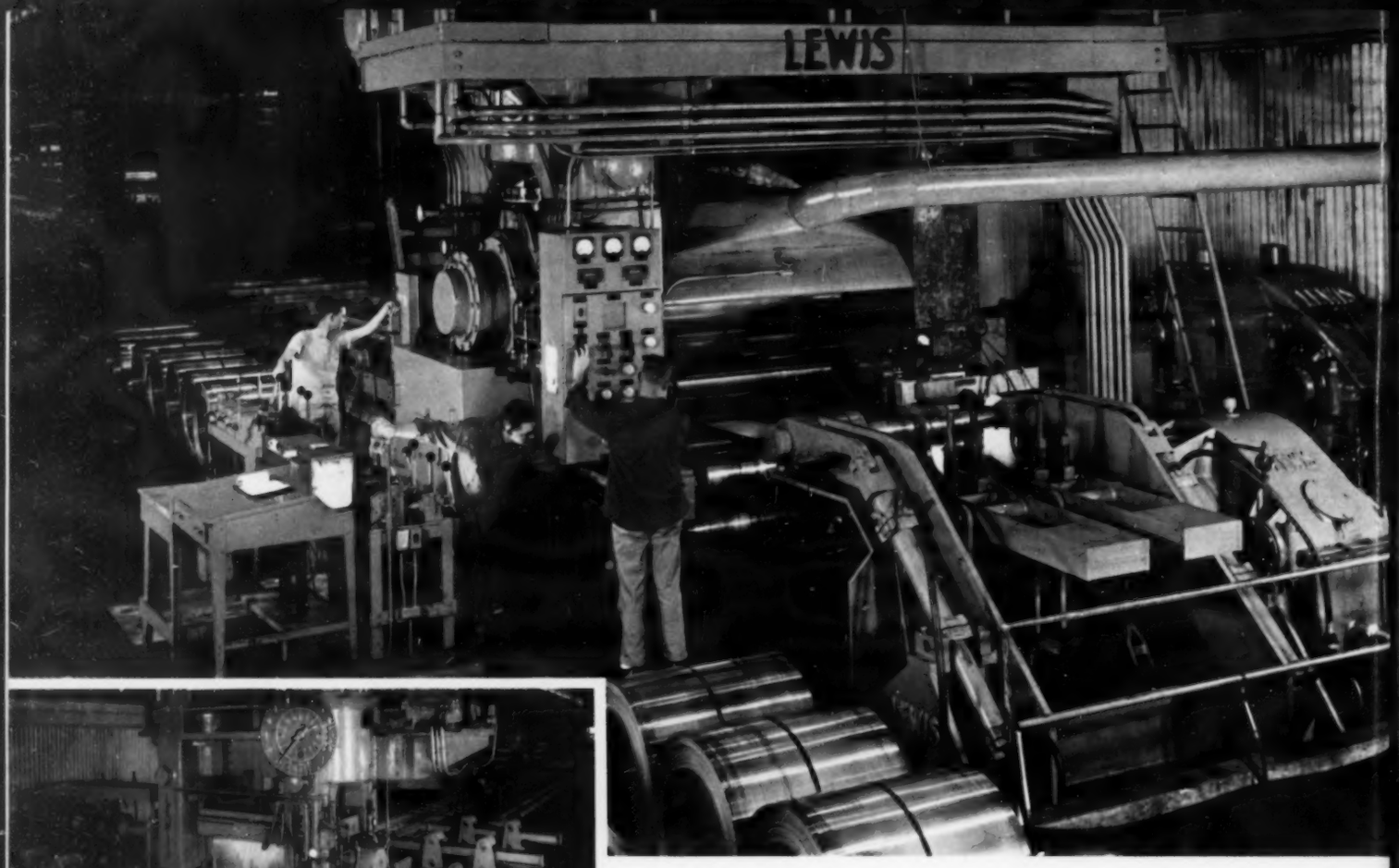
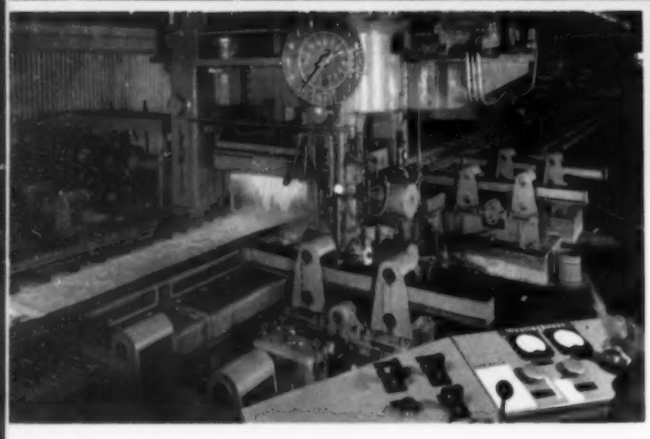
BLAW-KNOX

## BLAW-KNOX COMPANY

*Foundry and Mill Machinery Division*
*Blaw-Knox Building · 300 Sixth Avenue*
*Pittsburgh 22, Pennsylvania*




15 and 36 x 69-inch 4 high mill at Aluminum Foils, Inc., Jackson, Tennessee, for reducing aluminum strip to foil thicknesses. Dual coolant system permits use of mill for both hot and cold rolling.



30 x 70-inch 2 high hot reversing mill at Aluminum Foils, Inc., Jackson, Tennessee, reduces 10-inch, 3000 lb. aluminum ingots to finished strip 0.250 inch thick x 60 inch maximum width.

# BLAW-KNOX ALUMINUM REDUCTION MILLS

Blaw-Knox designs and builds a full range of mills for the reduction of Aluminum and other non-ferrous metals. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations including all auxiliary equipment for ferrous and non-ferrous metals, iron, alloy iron and steel rolls, Medart cold finishing equipment, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings.

BLAW-KNOX

## BLAW-KNOX COMPANY

*Foundry and Mill Machinery Division*
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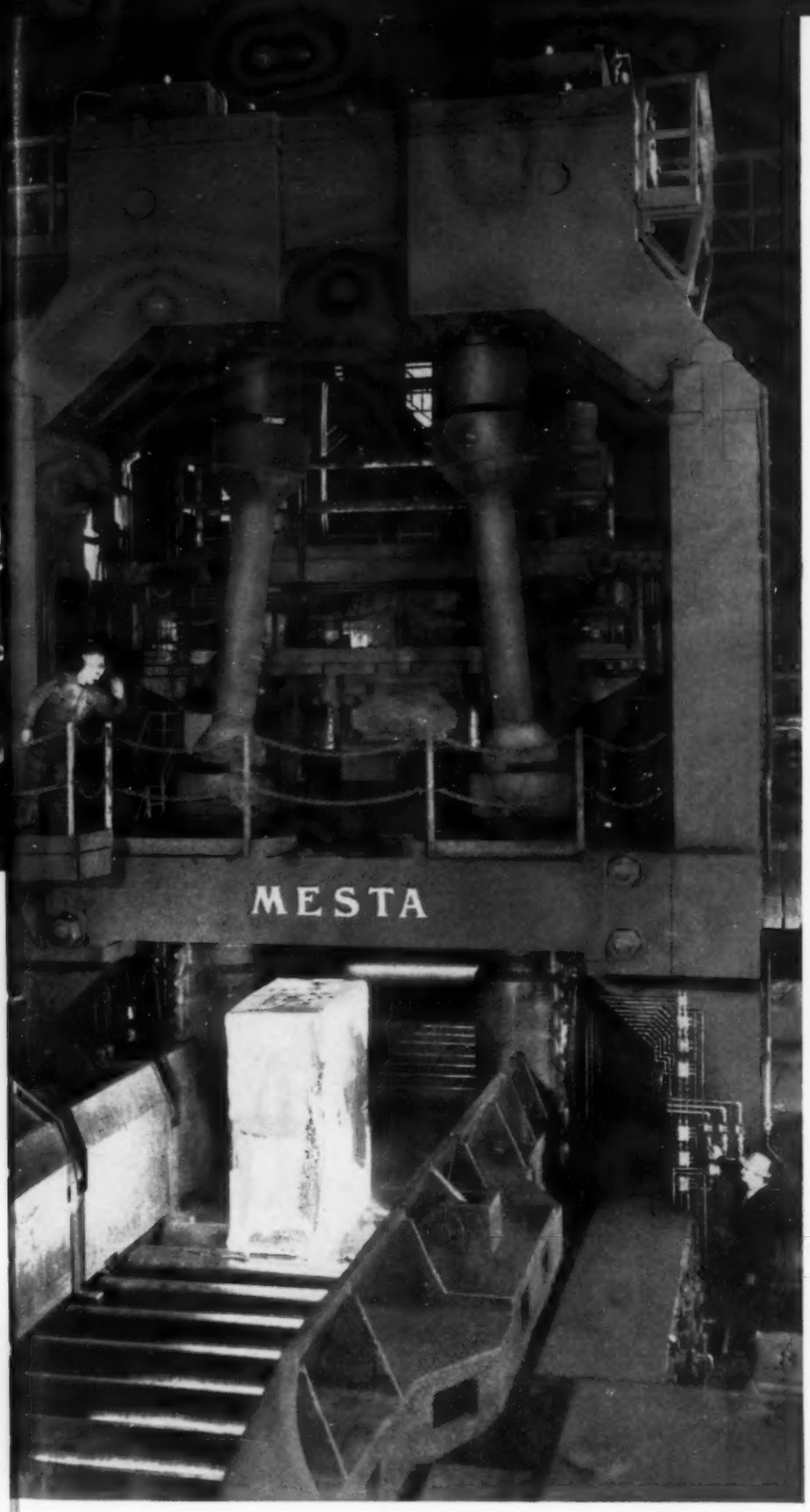



Experienced engineering and development

# KEY TO HIGHER TONNAGE

...with Westinghouse-equipped reversing mills

Knocking down an ingot on schedule places heavy demands on your primary reversing mill. Drives and auxiliary equipment take rough abuse. To give you an edge in meeting demands, Westinghouse drives are engineered from long experience. New advances in Westinghouse automatic controls and coordinated auxiliary equipment keep your mill on schedule.

MP-3051

YOU CAN BE SURE...IF IT'S Westinghouse

Dependability is tailor made

# Experience tailors each drive

Today, reversing mill drive equipment takes heavier abuse than ever before. Growing operating and tonnage requirements can't be met by yesterday's set of standards. That's why experienced engineering at Westinghouse tailors each drive to the specific mill. In this way, you can be sure of top performance, maximum accessibility to all parts of the drive, and rugged construction quality for reliability today and long into the future.

The Westinghouse reversing mill drive, at right, is a good example. Main drive is a 12,000 hp., 40 80 rpm double-armature twin motor. Edger drive (top) is a 4,000 hp., 60 150 rpm double-armature motor. Time-saving accessibility is provided by: 1) large walk-in endbells, 2) extra space for brush accessibility, both radially and axially, and 3) absence of baffle restrictions between the commutator area or the stator or rotor windings.

**Heavy-duty thrust bearings** are located at the mill end of the main drive pedestal bearings to permit easy, routine inspections. Removable end-case permits complete inspection and maintenance without disturbing either journal bearing or bearing cap.

**Rugged construction** of the Westinghouse reversing mill drive incorporates heavy-duty bedplates supported on concrete foundations. Pedestal cap bolts and base bolts extend deep into foundation concrete. Mill-end bearings are supported by massive pedestals using foundation keys. Each armature coil is rigidly and individually braced, front and rear. Armature coil cross connections are securly encased in a steel box at the rear of the rotor and flexibly connected to armature coils.

**Oscillotrol (R)** thrust oil-damper system effectively damps out rotor oscillations caused by pulses from mill-spindle coupling action on two-drive motors.

MP-3051

**YOU CAN BE SURE...IF IT'S Westinghouse**

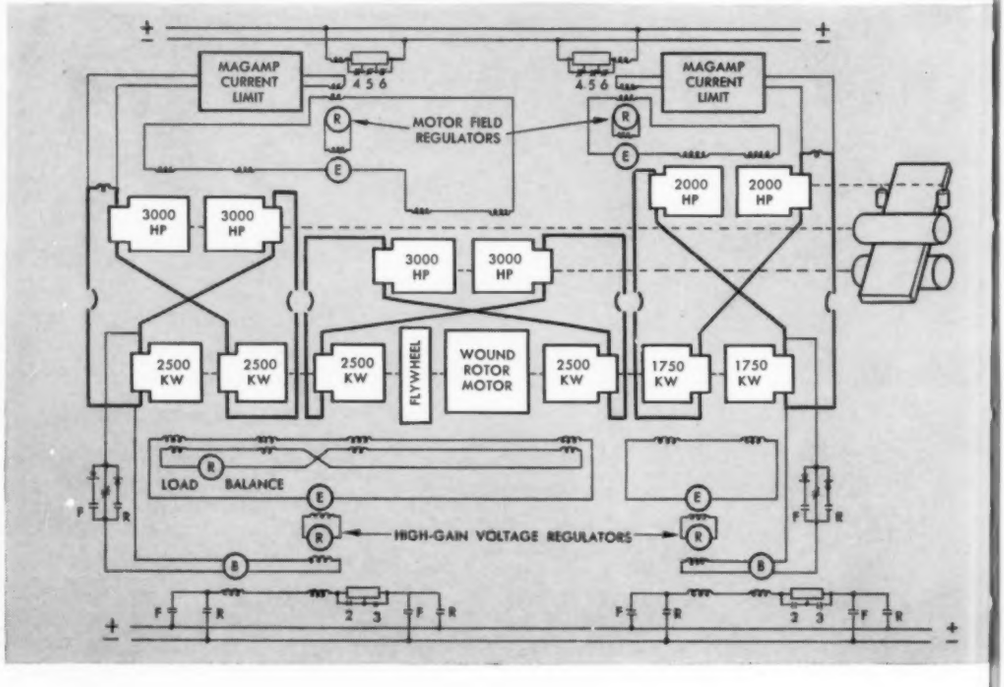
## SYSTEM FEATURES

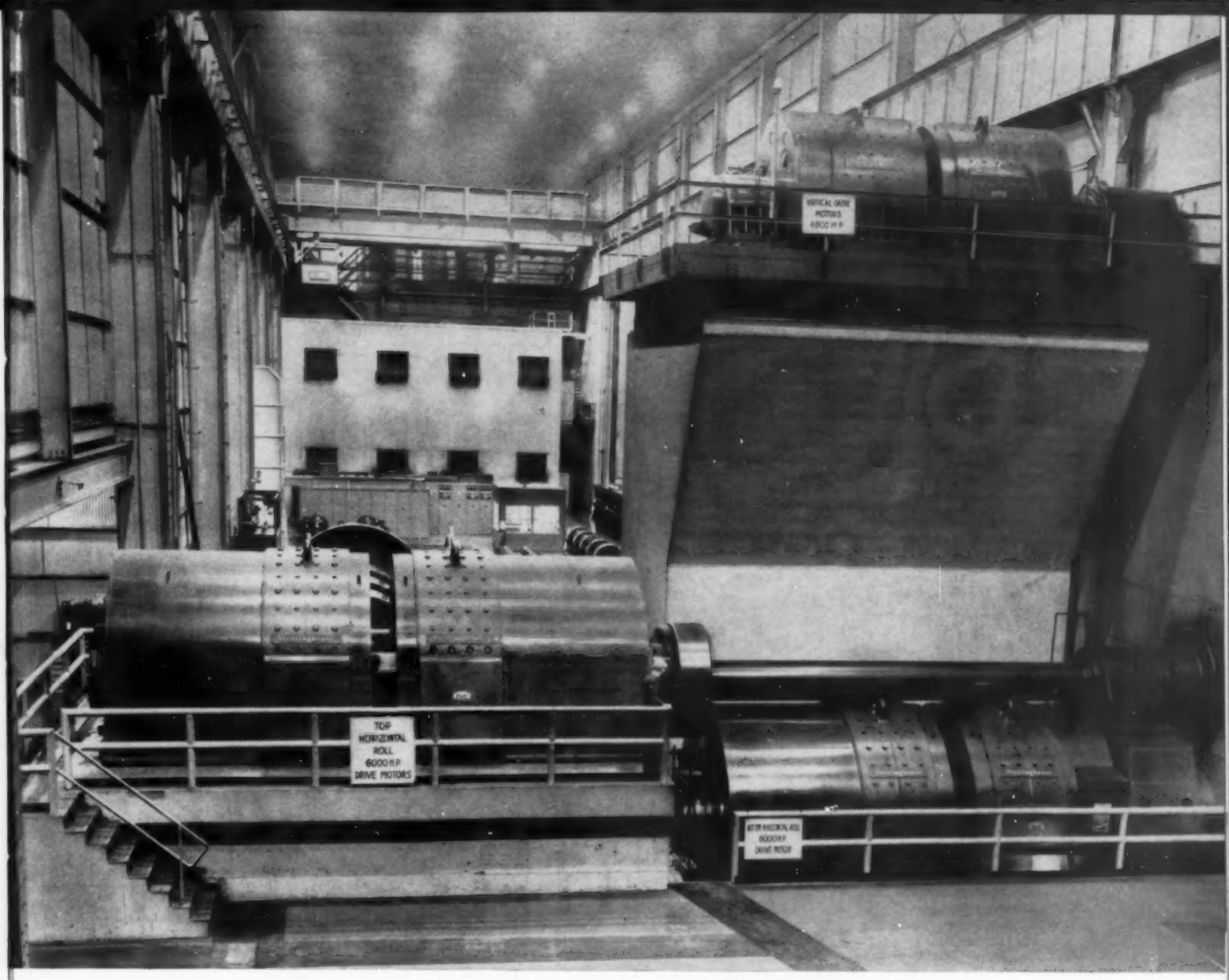
**Sandwich series** loops are used for each of the pairs of double-armature twin-drive motors and for the double-armature edger motor to minimize the number of circuit breakers and load balance equipment. A load balance regulator excites auxiliary fields on the 2500 kw generators to balance the twin-drive motor loads.

**High-gain voltage** regulators excite generators to give fast changes in response to the operator's controls.

**Motor field regulators** excite motors to give changes in speed by motor-field control.

**MAGAMP (R)** (magnetic amplifier) current-limit regulator builds up motor field strength to increase the torque per ampere for loads approaching 200%.






**Typical reversing mill drive using 12,000 hp, 40/80 rpm double-armature twin motor. Edger drive (top) is 4,000 hp, 60/150 rpm double-armature motor.**

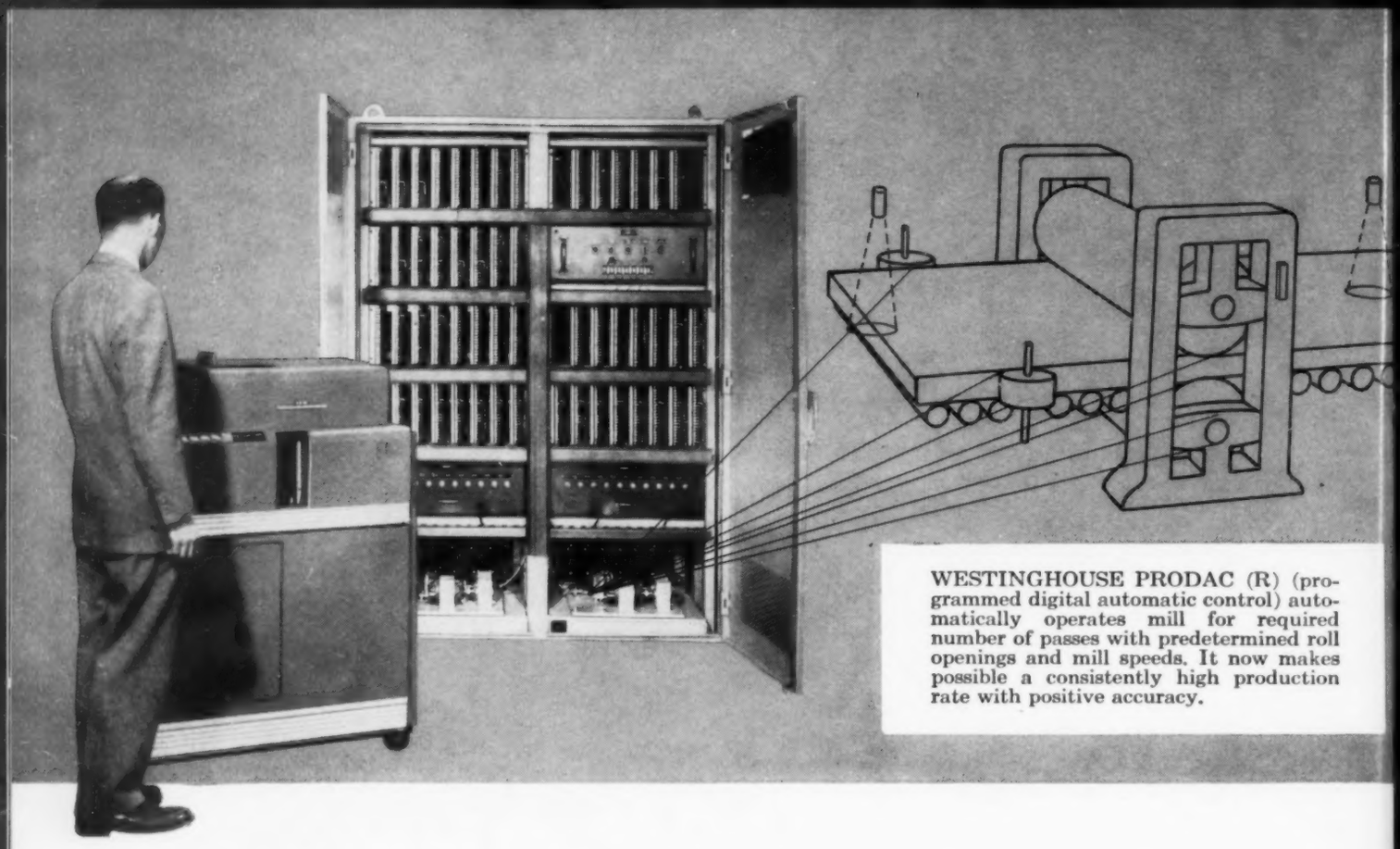
## WESTINGHOUSE EQUIPMENT SERVES THESE USERS

| YEAR | CUSTOMER | LOCATION | MILL | HP | RPM |
|---|---|---|---|---|---|
| 1951 | U. S. Steel Corporation | Fairless Hills, Pa. | 40″ Blooming Mill | 8000* | 65/130 |
| 1951 | ☆Sheffield Steel Division | Kansas City, Mo. | 32″ Blooming Mill | 4000 | 60/150 |
| 1951 | Laclede Steel Company | Alton, Illinois | 35″ Blooming Mill | 5000 | 60/150 |
| 1951 | Dow Chemical Company | Madison, Illinois | 84″ Reversing Mill | 6000 | 55/156 |
| 1951 | U. S. Steel Corporation | Morrisville, Pa. | Universal Slabbing Mill | 12000*† | 40/80 |
| 1951 | °Great Lakes Steel Corporation | Detroit, Michigan | Universal Slabbing Mill | 12000*† | 40/80 |
| 1953 | Reynolds Metals Company | McCook, Illinois | 144″ Taper Mill | 3000 | 125/250 |
| 1954 | Inland Steel Company | Indiana Harbor, Ill. | Wide Flange Beam Mill | 7000† | 80/160 |
| 1955 | Aluminum Company of Amer. | Davenport, Iowa | 160″ Slabbing Mill | 7000* | 30/60 |
| 1955 | Empressa Nacional Siderurgica | Spain | 132″ Plate Mill | 7000* | 40/80 |
| 1955 | Jones & Laughlin Steel Corp. | Cleveland, Ohio | Slabbing Mill | 10000* | 40/100 |
| 1955 | Kaiser Al. & Chem. Corp. | Ravenswood, W. Va. | 168″ Slabbing Mill | 10000*† | 30/60 |
| 1955 | Kaiser Al. & Chem. Corp. | Ravenswood, W. Va. | 110″ Slabbing Mill | 6000 | 30/60 |
| 1955 | Republic Steel Corp. | Cleveland, Ohio | Universal Slabbing Mill | 12000* | 40/80 |
| 1955 | Jones & Laughlin Steel Corp. | Aliquippa, Pa. | Reversing Rougher | 6000* | 40/100 |
| 1955 | Jones & Laughlin Steel Corp. | Cleveland, Ohio | Reversing Rougher | 8000* | 40/80 |
| 1955 | Crucible Steel Co. of Amer. | Midland, Pa. | Roughing Mill | 3500 | 50/150 |
| 1955 | Armco Steel Corporation | Butler, Pa. | Reversing Rougher | 7000 | 40/100 |
| 1956 | U. S. Steel Corporation | South Chicago, Illinois | Universal Slabbing Mill | 12000*† | 40/80 |
| 1956 | U. S. Steel Corporation | Gary, Indiana | Universal Slabbing Mill | 12000*† | 40/80 |
| 1956 | Altos Hornos | Mexico | Blooming Mill | 6000* | 40/80 |
| 1956 | Large Eastern Steel Company | | Blooming Mill | 3000 | 60/150 |
| 1956 | Reynolds Metals Company | Listerhill, Alabama | 170″ Slabbing Mill | 7000* | 30/60 |
| 1956 | Tata Iron & Steel | India | Reversing Rougher | 3500* | 60/150 |
| 1956 | Kaiser Steel Company | Fontana, California | 90″ Slabbing Mill | 10000* | 40/100 |
| 1956 | Olin Mathieson Chem. Corp. | Omal, Ohio | 96″ Slabbing Mill | 5000 | 35/70 |
| 1956 | Empire Steel Corporation | Mansfield, Ohio | Reversing Rougher | 5000 | 50/120 |

☆Armco Steel Corp. °Division of National Steel Corp. *Twin Drive †Double Armature

MP-3051

**Auxiliary equipment takes over more responsibility**



WESTINGHOUSE PRODAC (R) (programmed digital automatic control) automatically operates mill for required number of passes with predetermined roll openings and mill speeds. It now makes possible a consistently high production rate with positive accuracy.

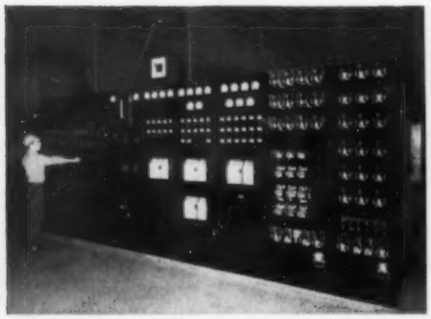
# Reversing mills are more precise, automatic with Westinghouse auxiliaries

Continued research and development by Westinghouse helps to make your operations more precise and automatic. A recent example is PRODAC control. It makes possible the first completely automatic mill with card-programmed rolling information.

Unmatched Westinghouse engineering for high-tonnage reversing mill operation is at your service . . . from planning to design, installation and start-up. A skilled Westinghouse team will accept unit responsibility and work with you and your consulting engineers.

Contact your Westinghouse sales office for further details . . . Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pa.

MP-3051

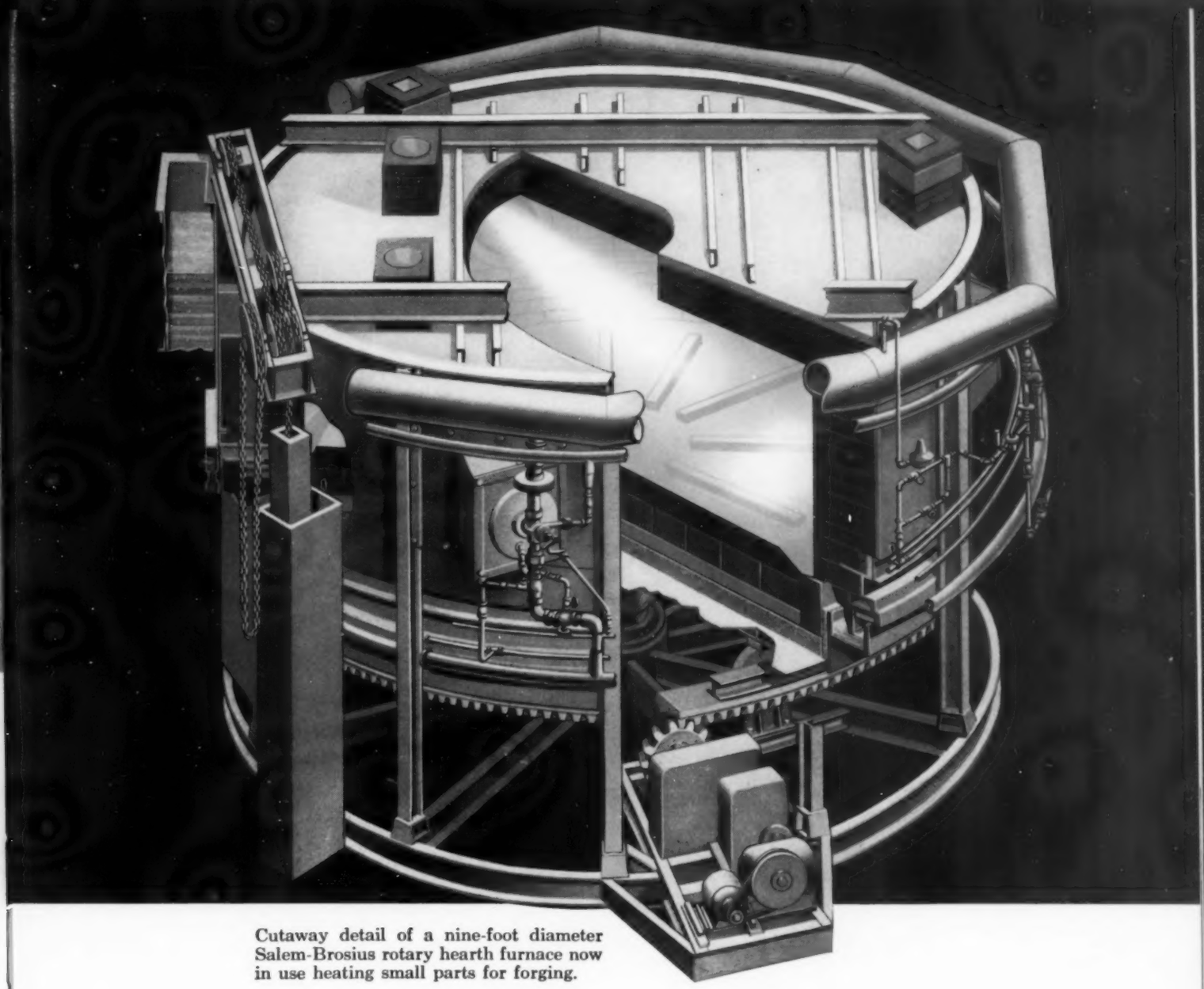


**WESTINGHOUSE** main-drive control panels provide centralized start-up switches for fans and motor-generator sets, and metering for power and regulating circuits.

**WESTINGHOUSE** variable voltage control for all auxiliaries minimizes handling time. Transfer switches and emergency bus arrangement afford relief in case of generator failure.

**MCT600 INDIVIDUAL TABLE ROLL MOTOR,** silicone insulated; drives mill tables directly; in ratings at 230 volts; frame sizes from 604 to 618; 3.75 hp to 50 hp, 157 rpm to 85 rpm.

YOU CAN BE SURE... IF IT'S Westinghouse



Cutaway detail of a nine-foot diameter Salem-Brosius rotary hearth furnace now in use heating small parts for forging.

# This Salem-Brosius rotary furnace in your forge shop saves you money

Companies producing parts for aircraft, automobiles, farm machinery, home appliances and a host of other products find the most economical and efficient furnace they can use to heat parts for production forging is the rotary type shown here. Burners are tangentially placed, and the heat is accurately controlled and uniformly distributed throughout the furnace chamber. The speed of rotation may be varied and is precisely set to the need of the product.

There is no practical forge heating method known that can equal the high production, low maintenance, low fuel cost, and uniformity of product heating of these specially designed rotary hearths. Salem-Brosius has designed and built more rotary hearth furnaces than any other company in the world. Write to us for further information.

## SALEM-BROSIUS, INC.

CARNEGIE, PENNSYLVANIA

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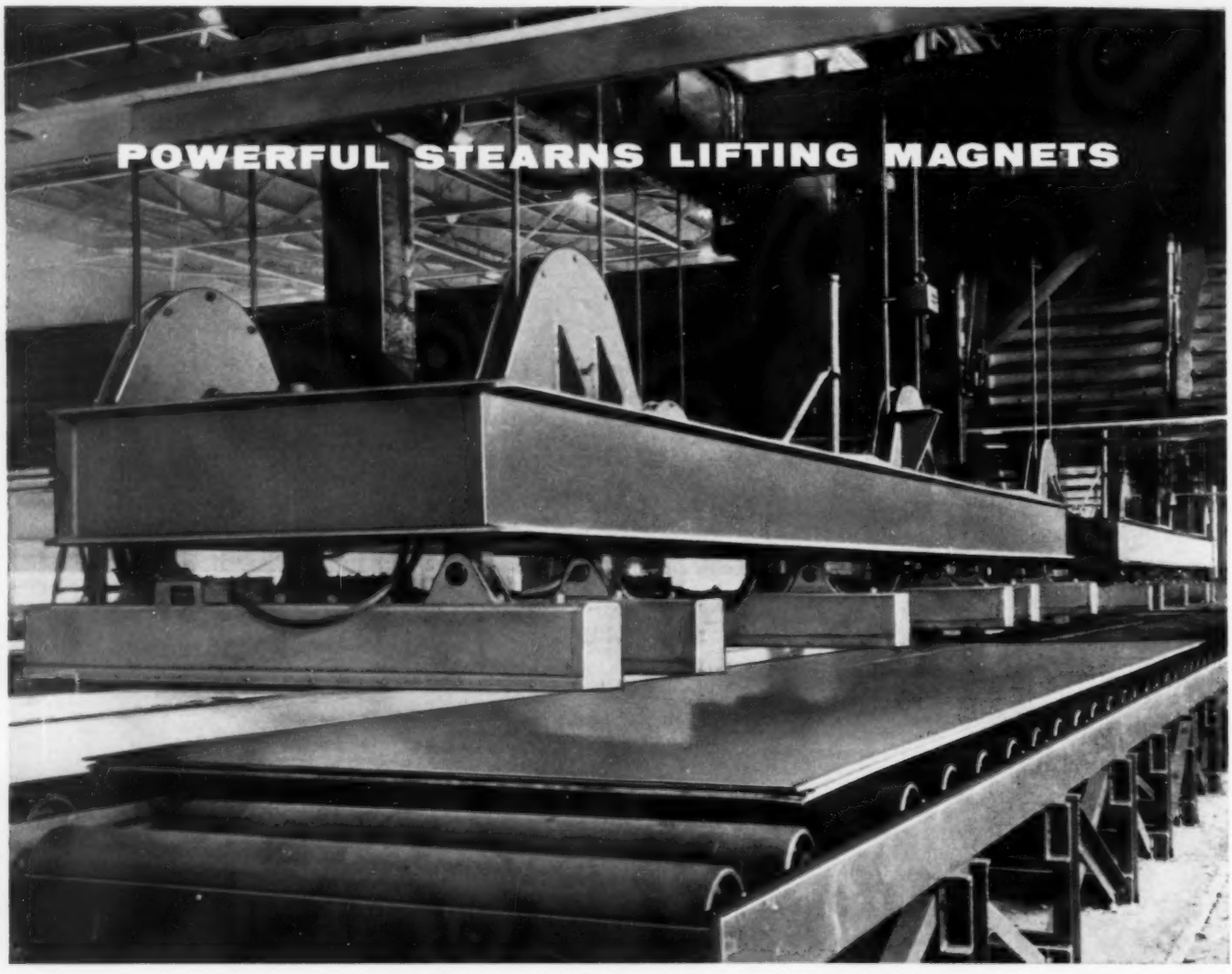
SPECIAL MECHANICAL EQUIPMENT • INDUSTRIAL HEATING FURNACES • MATERIALS HANDLING EQUIPMENT




Heavy sheets in a large eastern steel mill leap up from conveyor rolls as powerful Stearns deep-field magnets come down for a lift. Six-magnet assembly on huge hoist frame can handle any lift, place it where it's needed swiftly, safely, accurately.

# *put JUMP into heavy steel-handling jobs*

Handling transfer of heavy sheets and billets... quickly moving plates, bars, ingots, pipe . . . lifting crated iron and steel goods — Stearns rectangular lifting magnets are paying their way in large and small mills and foundries everywhere.

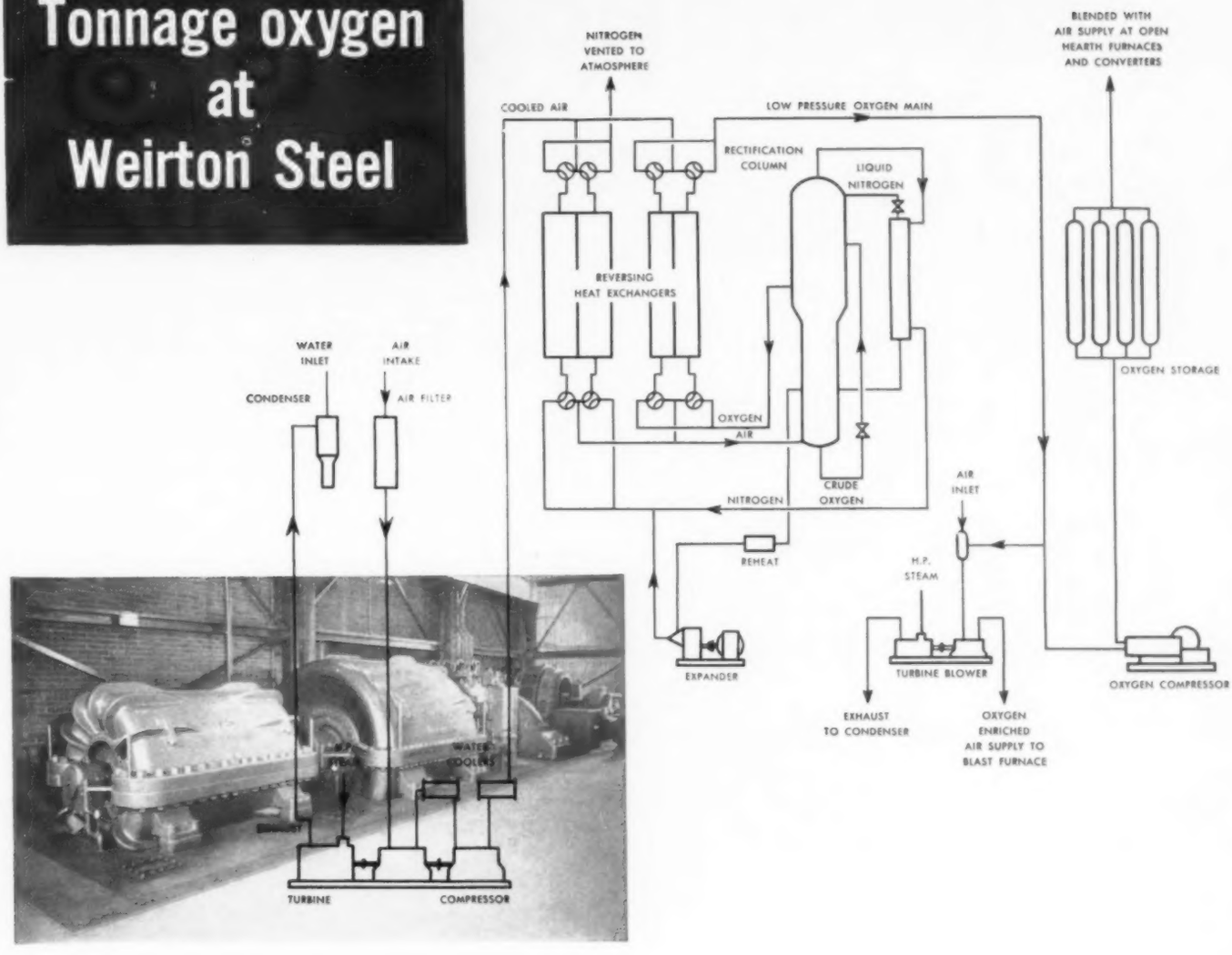
Stearns lifting magnets are quality-built for years of trouble-free service. Heavy-duty construction and rugged insulation assure dependable performance hour after hour on the toughest material handling jobs. You get more out of these units because Stearns puts more into them.

Stearns builds both rectangular and circular lifting magnets for practically any application, with capacities to match your requirements. Call your Stearns representative . . . or write for free literature. Ask for Bulletin 35-CI. 53

**STEARNS MAGNETIC PRODUCTS**

635 SOUTH 28TH STREET • MILWAUKEE 46, WISCONSIN

# Tonnage oxygen at Weirton Steel




## Ingersoll-Rand turbo-compressors cycle air in Weirton's 450-ton per day oxygen plant

"THE Weirton Steel Company Division of the National Steel Corporation started the operation of a tonnage oxygen plant in February 1951, and has operated this plant for the past *six* years making an average daily production of about *460* tons of oxygen for blast furnace and steel plant usage. During this *six*-year period the oxygen plant has produced *750,000* tons of 95 per cent purity oxygen, of which about *650,000* tons have been used for the enrichment of the blast for blast furnace iron production."

*Julius H. Strassburger, Assistant Vice President, National Steel Corporation.*

For the main air blower in this oxygen plant, which was designed and built by Air Products, Inc., an Ingersoll-Rand tandem turbo-compressor was selected. Pictured above is the high-pressure end of the compressor arrangement. The low-pressure unit delivers air at about 35 to 40 psig through a double intercooler to the second unit, where it is further compressed and discharged at pressures from 75- to 90-psig. The two compressors run in series and are driven by an Ingersoll-Rand steam turbine rated at 10,610 bhp at 3300 rpm.

Among the advantages of oxygen enrichment of the blast, according to Mr. Strassburger, are these: increased iron production with less "cost above Materials;" less flue dust per ton of iron; 25 to 50 lbs of coke saved per ton of iron; increased Btu of the top gas due to less nitrogen; no detrimental effect on furnace linings.

If you are interested in more complete details on the use of I-R turbo-compressors in tonnage oxygen production, contact your nearest Ingersoll-Rand engineer.

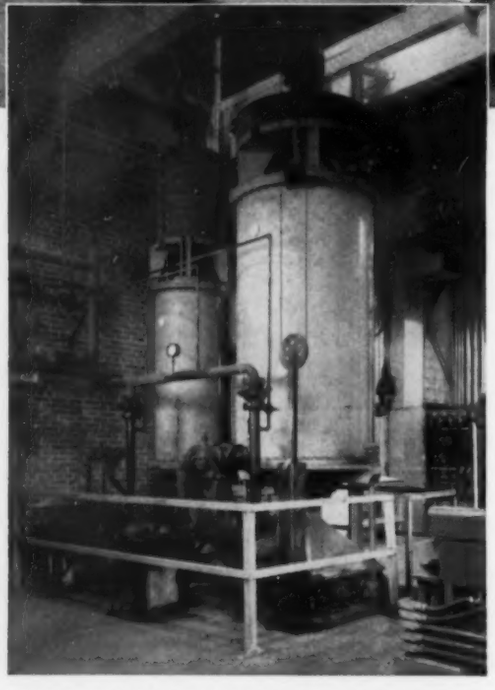
**Ingersoll-Rand** 12-600

**11 Broadway, New York 4, N.Y.**

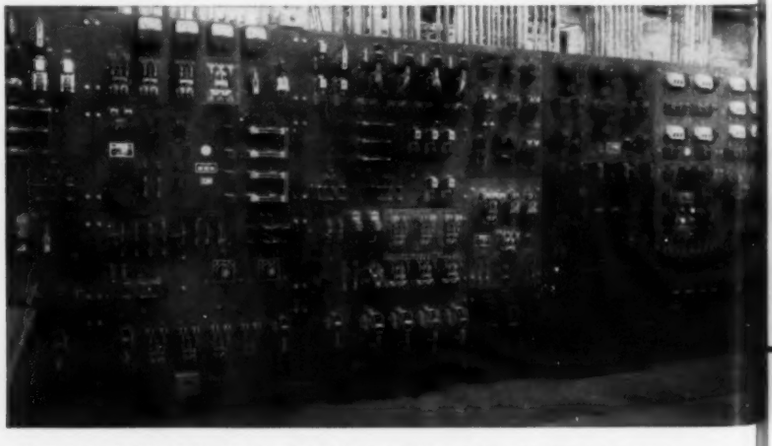
**PUMPS • COMPRESSORS • DIESEL ENGINES • AIR & ELECTRIC TOOLS • TURBO BLOWERS • CONDENSERS**

# How Koppers Helps

**NEW BLAST FURNACE** has a hearth diameter of 25 feet (expandable to 26 feet, 6 inches). Furnace was built off-site, then moved 84 feet into final position. This unusual method of construction minimized pig iron production loss and saved over 30 days' downtime.



**FREYN-DESIGN PNEUMATIC BELL HOIST** uses cold blast air for operating power—is engineered to provide long life with little maintenance.



**FREYN-DESIGN CHARGING CONTROL EQUIPMENT** automatically controls the skip hoist, bell hoist, stockline recorder, revolving distributor, as well as coke breeze handling.

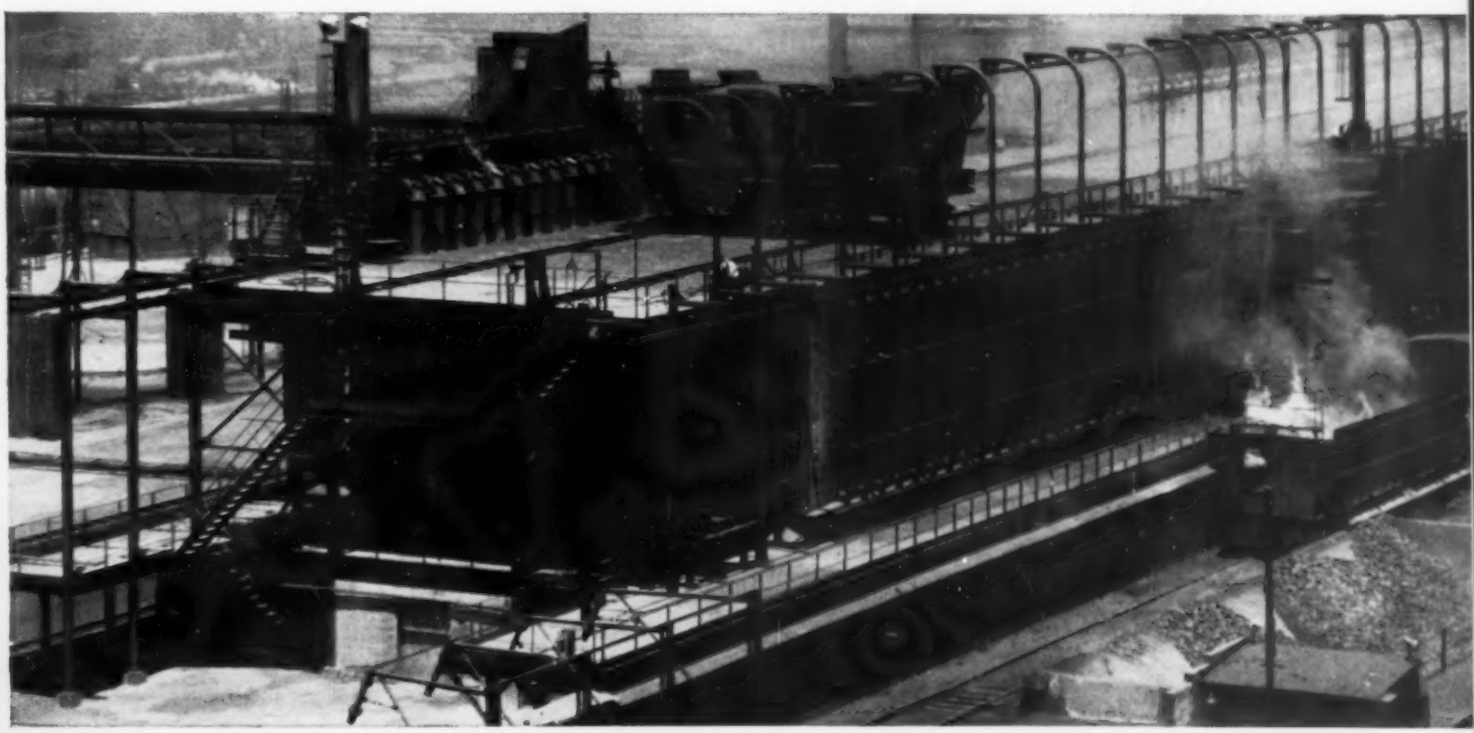
# Boost Capacity at Granite City Steel

The present expansion program at Granite City Steel Company, Granite City, Ill., called for an increase of 30 per cent in annual ingot capacity. Koppers is happy to have been chosen to help meet this objective by providing a battery of 27 Koppers coke ovens, and a new blast furnace complete with Koppers electrostatic precipitator and Freyn-Design charging equipment, including skip hoist, pneumatic bell hoist and charging control.

In operation since October, 1956, the new Koppers furnace has a capacity of approximately 1,200 net tons of iron a day —*twice* that of the furnace it replaced. This installation is an important step in the progressive planning and development of Granite City Steel Company.

*Koppers Company, Inc. and its Freyn Department offer complete metallurgical engineering and construction services in every phase of steel mill operation. You are cordially invited to consult with our engineers and management.*

Koppers Company, Inc., Pittsburgh 19, Pa.



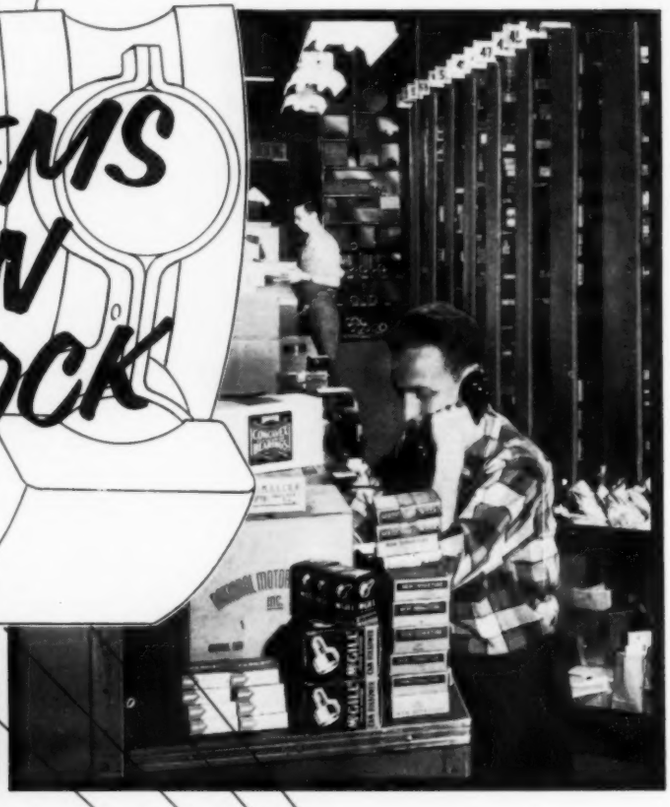
**COKE OVEN BATTERY** added in 1953 consists of 27 Koppers-Becker Underjet ovens. This is the second battery of coke ovens built for Granite City Steel by Koppers. An earlier battery was installed in 1942.

KOPPERS®

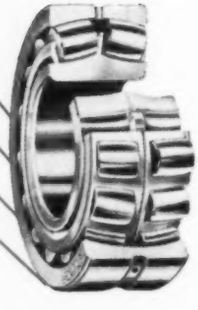
**KOPPERS**

**ENGINEERING AND CONSTRUCTION**

# 50,129 ITEMS IN STOCK



**With more than 22 miles of shelves--stacked with bearings ... bearing specialties ... and ... transmission appliances --Berry can give you *IMMEDIATE DELIVERY* on every order**



For each of the last 37 years, more and more midwest industrial bearing users have been ordering from Berry Bearing Company. They have learned that from Berry they can get exactly what they need ... and ... get it in a hurry, too--regardless of the size of the order.

Berry is the authorized stock carrying distributor for 41 of the nation's leading manufacturers of bearings, bearing specialties, and transmission appliances. And, Berry has one of the largest and most diversified stocks in the United States--over 50,129 items--each one ready for immediate delivery. Like thousands of other bearing users, you'll save time, effort, and money--when you order from Berry.

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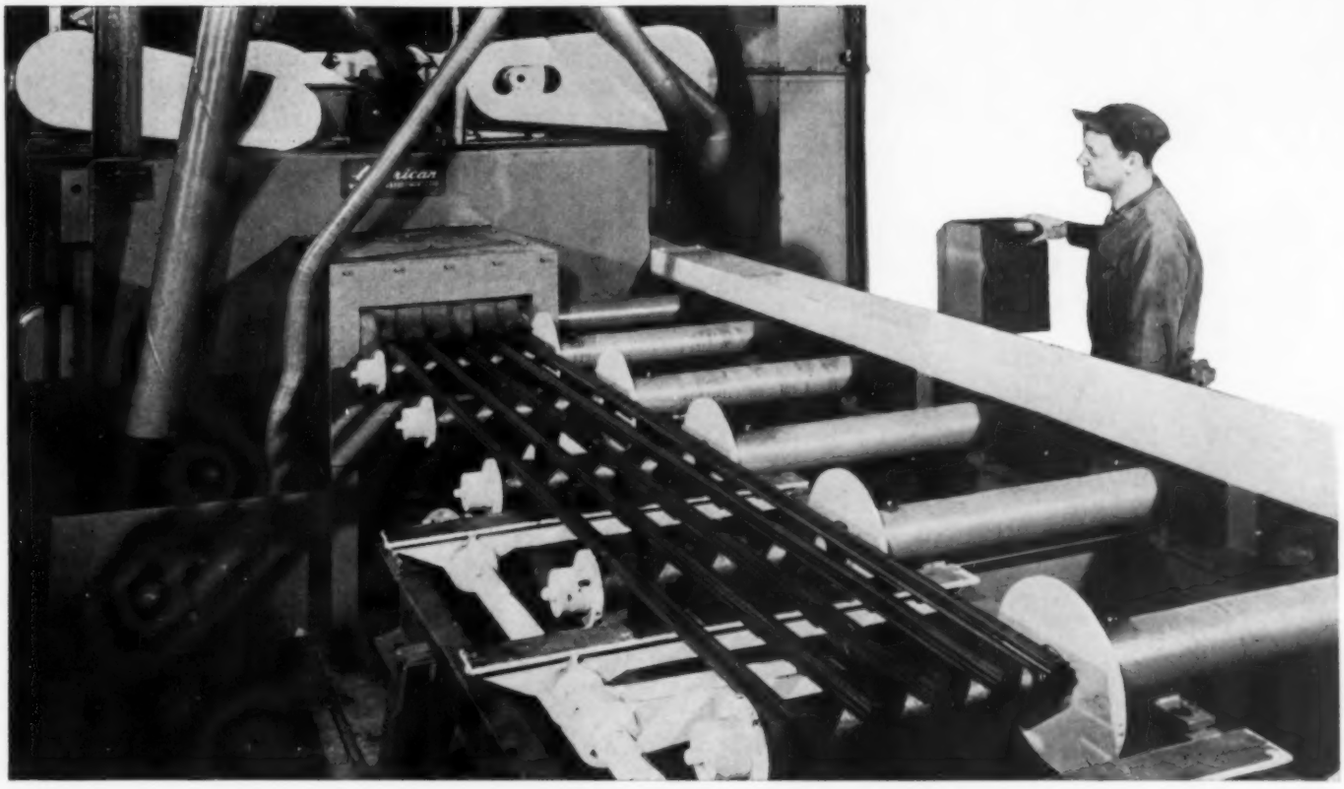


# *In Cleaning Bar Stock for Cold Drawing*

## WHEELABRATOR®

### *Mechanical Descaling*

**REDUCES COSTS — INCREASES PRODUCTION**
**REDUCES AT LEAST 90% OF ACID PICKLING NEEDS**

Mechanical descaling with Wheelabrator airless abrasive blast cleaning greatly reduces the time formerly required by the slower, more costly method of pickling mill lengths of bars and thus speeds cleaning production while effecting significant savings.

Wheelabrator equipment can be designed to suit nearly any production requirement, and work-conveying methods through the blast cabinet are engineered to fit product and production needs.

For instance, the unit shown here is designed to deglass and descale hot extruded bars at a prominent steel mill. (Powdered glass is used as a lubricant in the hot steel extrusion process.)

This installation handles five bars at a time on a roll-type conveyor. Four Wheelabrator units, in fixed position, are so arranged that all surfaces of the many different sections of the extruded bars are covered with the abrasive blast and are thoroughly cleaned. The bars are given a 3 to 5 minutes pickle, lime coated and cold drawn for final sizing of the shape to required tolerances. This operation has proved much cheaper and faster than the previous pickling process. It is also possible to eliminate the acid pickle and lime coating in some cases.

Other Wheelabrator mechanical descaling installations have saved at least $1 a ton on round bars by effecting savings through reduction in pickle time and increased production.

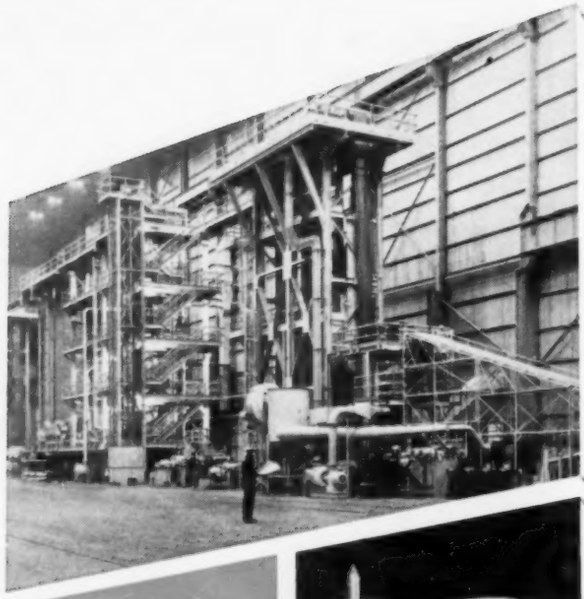
Wherever steel must be descaled, whether it's strip, sheet, bar stock, structurals, slabs or billets — Wheelabrator Mechanical Descaling replaces or drastically reduces acid pickling requirements and effects savings in time, space, manpower and overall costs.

**SEE HOW OTHERS SAVE**— Write today for this photo-filled, fact-packed, 8-page booklet that shows how Wheelabrator Mechanical Descaling is saving money in every phase of the steel industry. Ask for "Everywhere You Work with Steel."

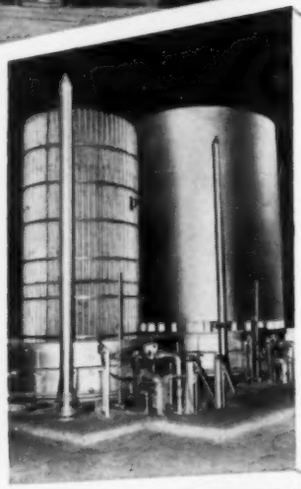
**WHEELABRATOR**
CORPORATION

**396 South Byrkit Street** **Mishawaka, Indiana**

*WORLD'S LARGEST MANUFACTURERS OF AIRLESS BLAST CLEANING EQUIPMENT AND STEEL ABRASIVES*

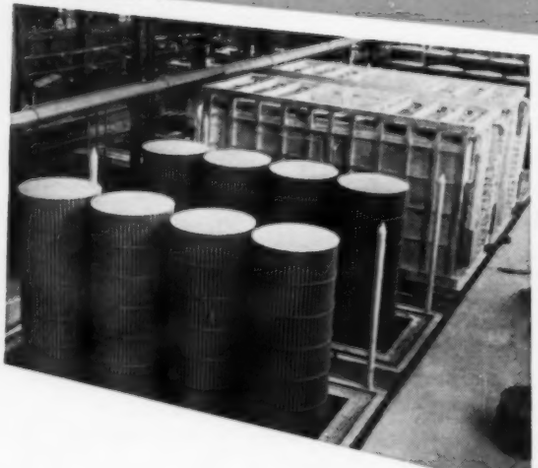


VERTICAL STRIP ANNEALER



SINGLE-STAND ANNEALERS

CONTINUOUS STRIP GALVANIZER

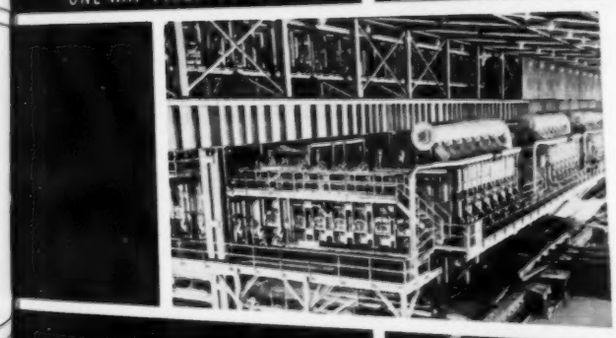


MULTIPLE-STAND ANNEALERS

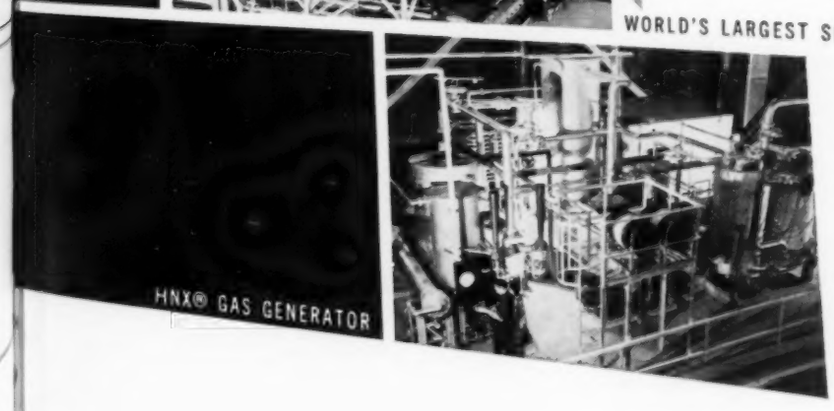
# foundation for steel mill profits

CARBOTTOM COVER FURNACE

ONE-WAY FIRED SOAKING PITS



WORLD'S LARGEST SLAB HEATER



HNX® GAS GENERATOR

You put a solid foundation under your profits whenever you specify Surface equipment. Whatever type it may be, you know it is supported by many interlocked blocks of know-how in heating and handling steel.

The technical skills which Surface has developed in building soaking pits will benefit the man who buys Surface annealing covers. In the same way, Surface concepts of slab heating contribute to high-speed stress relieving . . . carbon restoration to strip annealing . . . controlled atmospheres to wire patenting.

Because of this broad and deep foundation of experience, Surface can improve any single process in the context of a complete sequence of operations. This is to the customer's profit, as many companies will confirm.

Surface Combustion Corporation, 2404 Dorr St., Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ontario.

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# Save by using specialized refractories

Many refractories problems in metal-working furnaces have been solved *economically* by the use of B&W specialized refractory castables. Each ferrous or non-ferrous furnace application requires a specific combination of properties to meet the service conditions. Whether your problem is high temperatures, abrasion and erosion, slag attack or the need for insulation, to name a few, you will find the refractory castable best suited to your requirements in B&W's line. Shown here in digest form are data on the widely used B&W refractory castables for metal-working furnaces:

## B&W Refractory Castables for Metal Working Furnaces

| | Temp. F | PROPERTIES | TYPICAL APPLICATIONS |
|---|---|---|---|
| B&W Kaocast | 3000 | High resistance to spalling and slag attack. Low volume change and negligible reheat shrinkage. | Soaking pit covers, linings of high temperature heating and forging furnaces, burner blocks, electrode linings of electric furnace roofs, linings of non-ferrous metal furnaces. |
| B&W Kaocrete 32 | 3200 | High strength, exceptional refractoriness, unusual volume stability, excellent resistance to spalling. | Can be used in applications similar to those of B&W Kaocast and where higher refractoriness is required. |
| B&W Kaocrete D | 2500 | Sufficient strength and hardness to withstand abrasion, considerable physical abuse and erosion. | Aluminum melting furnaces, linings and car tops in heat treating furnaces, as well as in sections of a wide variety of furnaces that are subject to scraping by hand tools or other mechanical abuse. |
| B&W Kaocrete A | 2600 | Resists reducing atmospheres. Has good resistance to erosion, abrasion and thermal shock. | Annealing furnace bases and other applications where resistance to reducing atmospheres is essential. Also as a general purpose castable for linings in medium temperature service. |
| B&W Kaocrete B | 2300 | Has an adhesive plastic texture particularly suited for vertical or overhanging constructions. Excellent for plastering. | Patching linings and baffles and for any application where plastering rather than gunning or casting is required. |
| B&W Kaocrete LI | 2700 | High alumina content, exceptionally high strength for resistance to abrasion and erosion. | Aluminum furnace linings where high alumina content is important. |
| B&W Kaolite 20 | 2000 | Offers castable's fast, low cost installation plus insulation. Has refractoriness, light weight and low heat conductivity and, in addition, will resist reducing atmospheres. Can be poured or gunned. | Aluminum melting, heating and heat-treating, annealing and forge furnaces. Also for general maintenance and patching. |
| B&W Kaolite 22 | 2200 | Has the same properties as B&W Kaolite 20. Can be used for higher temperatures but not in reducing atmospheres. | |

Send for your copy of B&W Bulletin R-35. It gives additional information on B&W's versatile refractory castables.

**B&W REFRACTORIES PRODUCTS:** B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick • B&W Refractory Castables, Plastics and Mortars • B&W Silicon Carbide

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R561

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*Four years without fan replacement since installing*

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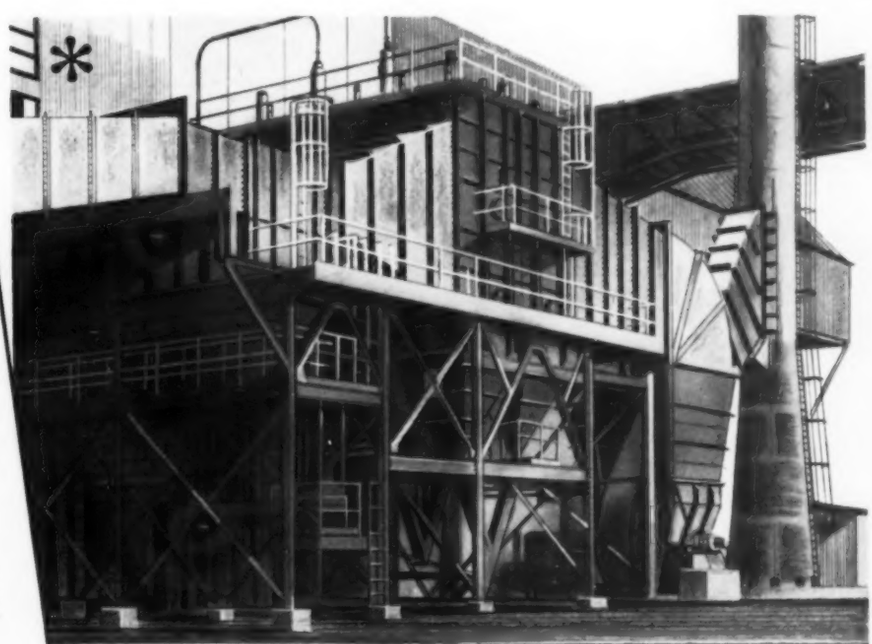
The experience of one major eastern steel company is particularly significant. Since installing Western Precipitation CMP Units four years ago, it has not been necessary to replace or repair a single fan in the plant systems these units serve.

Moreover, this CMP equipment has proven so satisfactory that this same company has ordered and reordered additional installations. *To date, six CMP installations are either already in service or are on order for this one plant!*

The CMP is another product pioneered by the industry's most experienced organization in dust, fume and fly ash recovery—Western Precipitation Corporation. Backed by Western Precipitation's years of know-how in both *electrical* (Cottrell) and *mechanical* (Multiclone) recovery principles, the CMP (Combination Multiclone - Precipitator) combines advantages of *both* these basic types into *one* compact coordinated unit. The Multiclone section mechanically separates all but the very finest suspended particles, and then the Cottrell section provides final clean-up with electrical ionization.

***Result:***

**Unusually high recovery efficiency at low installation and maintenance costs. Best of all, there is no "transfer wear" from sintering plant fans to recovery equipment, for CMP maintenance requirements are negligible.**



No matter what your recovery requirement, the know-how of the industry's most experienced organization in dust, fume and fly ash recovery is at your service. We are equipped to handle installations on either a complete "turnkey" basis, or supply equipment only, whether electrical (Cottrell), mechanical (Multiclone), filter (Dualaire)—or combination systems.

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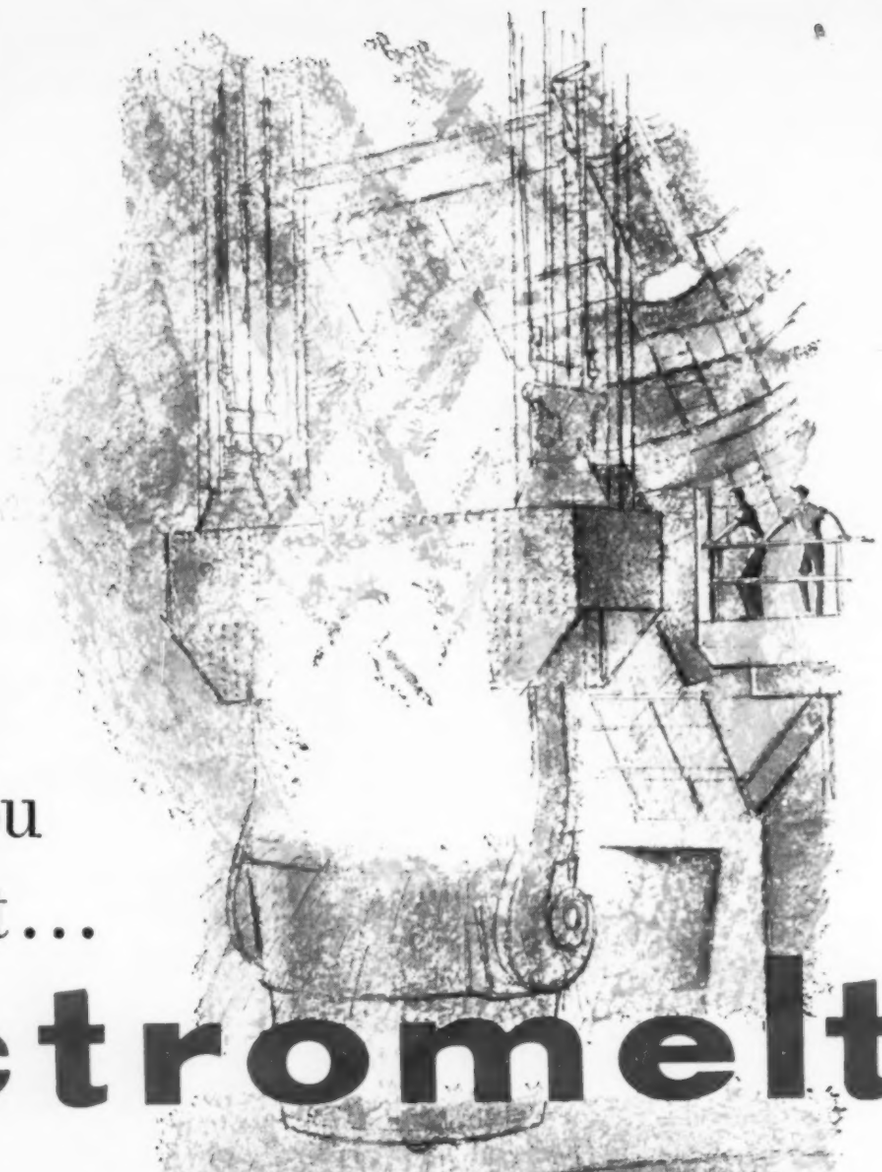

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Catalog 9-B describes efficient, time-proven Lectromelt furnaces and equipment.

*. . . . much of the increased open hearth capacity has been obtained by enlarging existing facilities . . . . these three papers show some of the methods used to do this . . . .*

# Increasing Open Hearth Capacity

## "FUEL'S CONTRIBUTION TO INCREASED OPEN HEARTH CAPACITY"

By

C. W. DUNN

Superintendent, Utilities Dept.

Fairless Works

United States Steel Corp.

Fairless Hills, Pa.

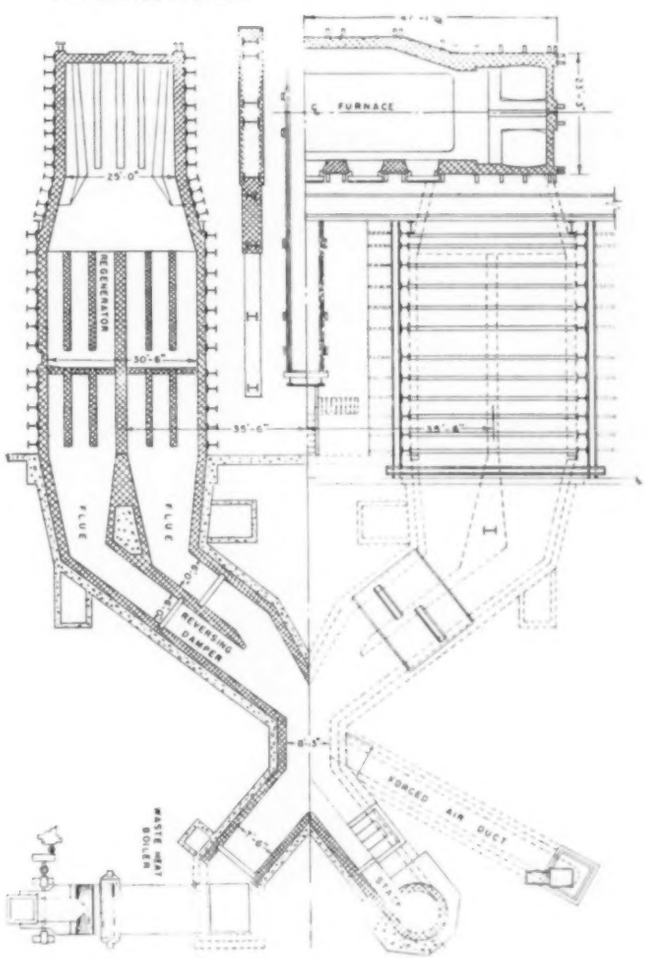
▲ THE 330-ton basic open hearth furnaces at Fairless Works are equipped with front flush, two-pass checkers, waste heat boilers and individual dust precipitators, as shown in the plan (Figure 1) and elevation (Figure 2).

In order to explain the general fuel picture, it might be well to describe the dual fuel system and method of delivery to the open hearth furnaces. The first fuel, 0.7 per cent sulphur bunker C fuel oil is delivered by barge shipments into a 6,500,000-gal storage tank at the dock and then pumped as necessary to four storage tanks, situated at the open hearth shop, each having a capacity of 150,000 gal. The oil is then pumped to the open hearth fuel loop, passing through secondary heaters for viscosity and temperature control before delivery, at 200 psi pressure, with recirculation provisions, to the furnaces. The second fuel is virgin tar, a by-product of the coking operation, which is delivered in the same manner as the fuel oil except that it is pumped directly to open hearth tar pumps from the coke plant storage area.

The type of burner used at Fairless Works (Figure 3) is designed for doghouse use and consists of three 1¼-in. standard pipes, 14 ft-8 in. long, swedged down to 1-in. standard pipe size at the discharge end. The top pipe is used for oil, the middle for oil or tar, and the bottom for flame enrichment oxygen. The maximum firing rate is 1000 gphr with 800 gphr a practical limit when using a single burner. When two fuels are used, tar is used as a base and the fluctuations are met by varying the oil as required. Several types of atomizers have been tried, but due to the availability of 300-psi steam, together with the ease of maintenance and the ability to control flame pattern at various fuel flows, it was felt that the tee atomizer gave the best results.

Fuel efficiency could hardly be accomplished without a means of measuring and controlling the combustion process. Fairless Works, being a new plant, is fortunate

**Figure 1 — Plan of arrangement of open hearth furnace at Fairless Works.**



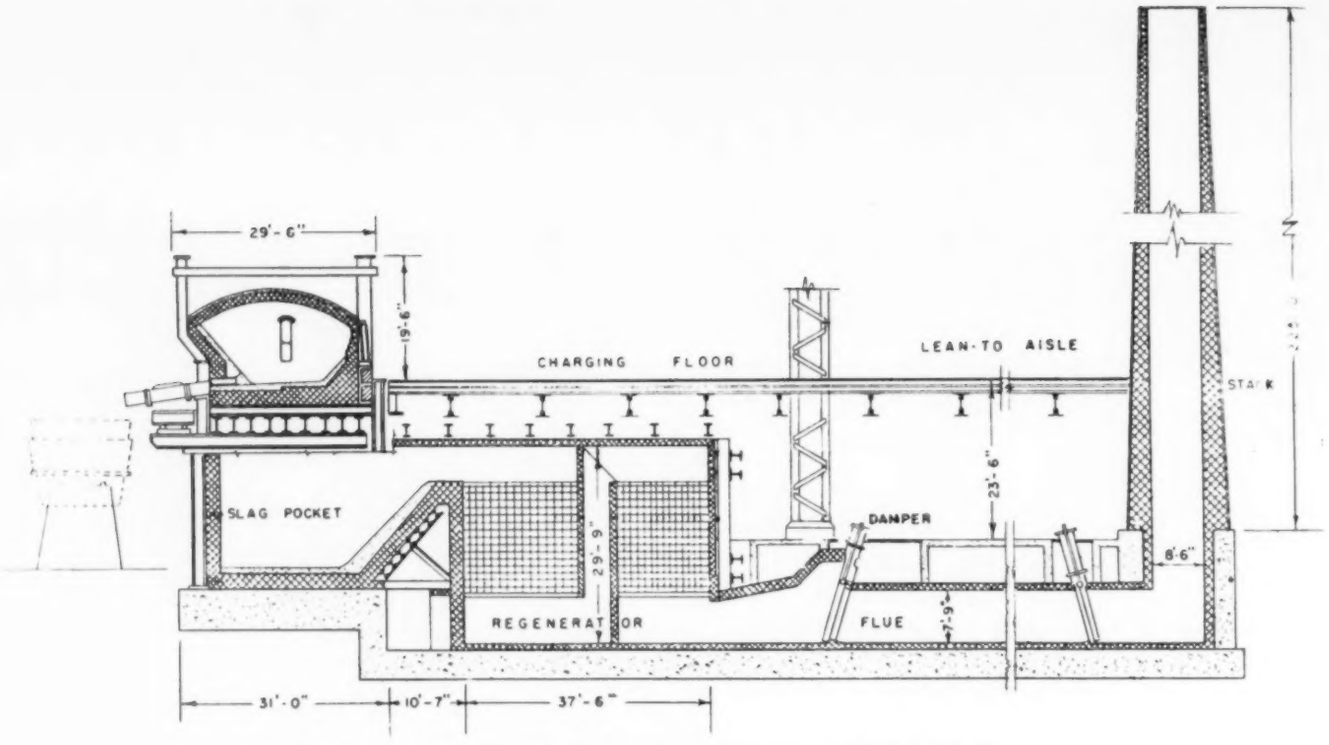



**Figure 2 — Elevation of open hearth furnace at Fairless Works.**

in that it could take advantage of the latest developments in instrumentation and control. Figure 4 is a picture of the instrument panel. Figure 5 is a descriptive sketch of the panel. With this system, it is possible to measure and control fuel-steam ratio, fuel-air ratio, furnace pressure, and roof and checker temperatures. The ability to measure these factors and control them automatically has provided a means of allowing furnace operators to spend more time on those variables that directly affect steelmaking processes and are not measurable on a continuous basis. The waste heat boiler (Figure 6) is equipped with instruments to measure superheater header outlet pressure and feed water pressure, record boiler drum level, inlet and outlet draft, steam flow, steam pressure, steam temperature, and inlet and outlet air temperatures. This instrumentation has aided in an overall furnace evaluation and, because of the progress in this field in the past few years, significant contributions to increase steel tonnage have resulted.

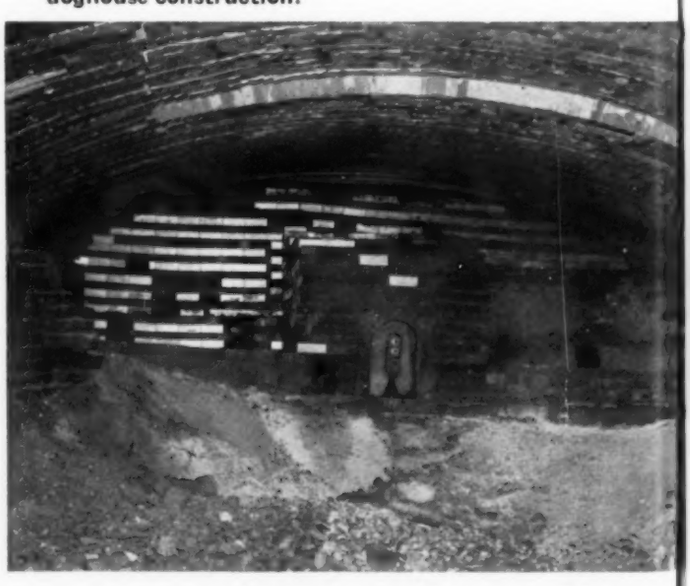
Our shop does not fall into a pattern from furnace to furnace, or from one campaign to another on the same furnace, so it is necessary to continually study the operating data for significant variations in both productivity and fuel performance. Many variations can be attributed to auxiliaries, raw materials and delays not directly associated with fuel practices. The residual variation remaining after the above have been taken into account can represent a substantial amount of money.

The fuels group in the open hearth consists of two fuel engineers, seven fuel analysts, and six instrument repairmen and apprentices. This group works in both an advisory and operational category as required by the open hearth department to strive for the following basic results: (1) maximum production, (2) minimum refractory consumption, and (3) minimum fuel use consistent with the above.

In order to approach the above considerations, it is necessary to have the group function so that people can perform the following work:

1. Operational and fuels trouble-shooting together with such routine tests as can be performed without too much time in any one location:
   A. Fuel engineer ..... ½
   B. Fuel analyst ..... 4
2. Preventive maintenance on process control equipment:
   A. Fuel engineer ..... ½
   B. Instrument repair apprentices ..... 4
3. Special Tests and Projects and Extensive Routine Testing:

**Figure 3 — Interior of furnace shows end wall and burner doghouse construction.**



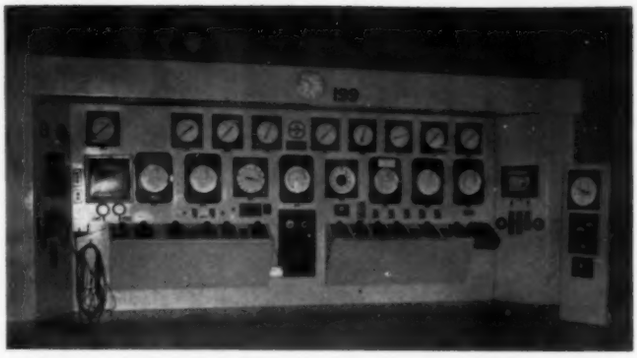


**Figure 4 — View of the instrument and control panel installed for each furnace.**

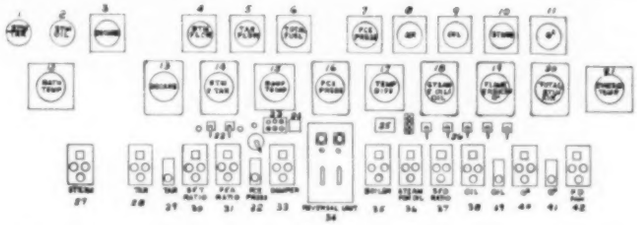


**Figure 5 — Descriptive layout of the instrument and control panel shown in Figure 4.**

A. Fuel engineer ..... ½
B. Fuel analyst ..... 2
C. Instrument repairmen ..... 2
(With help from central instrument shop as requested for temporary or permanent major installations.)

4. Analytical work such as graphical exhibits and correlation studies:
A. Fuel engineer ..... ½
B. Fuel analyst ..... 1

There is no attempt made to allocate the supervision as shown above, but it does represent an approximation of the time required by each phase of the fuel program.

Our instrument repair force is maintained in the open hearth to effect preventive maintenance and to install new systems or revise present systems, as better means are found to improve reliability, control and accuracy. Emphasis is placed on full utilization of present equipment.

Continuing attempts are being made to give the operator a control which will enable him to spend more time at the furnace, with minimum effort needed to establish proper combustion in the furnace.

One method employed was to install a single selector station which would permit reproducibility of steam and air flow rates at various fuel input rates, flexible enough to cover rates sufficient for any stage of the heat.

The primary object of this discussion is to present our thinking on increases in production as a result of the fuels group's contribution in testing and analysis. The program is designed to encompass both short (daily) and long range studies by plotting data continuously on many variables, looking for trends and drawing conclusions. Needless to say, the latter phase causes the most trouble and is the most difficult to accomplish.

Within the confines of the previously mentioned objective, the burning of fuel in an open hearth serves only two purposes: first, to supply a high-temperature heat input to support thermal requirements of the operation; and second, to do this without imposing any limitation on the chemical reactions required to refine steels. When driven fuel is completely burned within the furnace chamber (no combustibles and minimum $O_2$ to assure no combustibles), a part of the first purpose and all of the second purpose has been satisfied. The balance of the factors associated with the ability to efficiently supply adequate heat can be resolved qualitatively to variables affecting flame size and shape, flame emissivity and flame temperature.

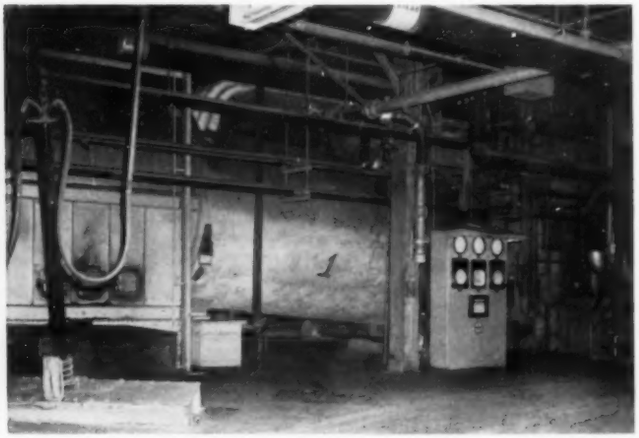
There are nine elements of combustion control for a single furnace and burner design that must be considered: (1) fuel rate (2) air rate (3) steam rate, (4) furnace pressure, (5) roof temperature, (6) steam temperature, (7) steam burner pressure (8) temperature of the driven fuel, and (9) angle and elevation of the burners.

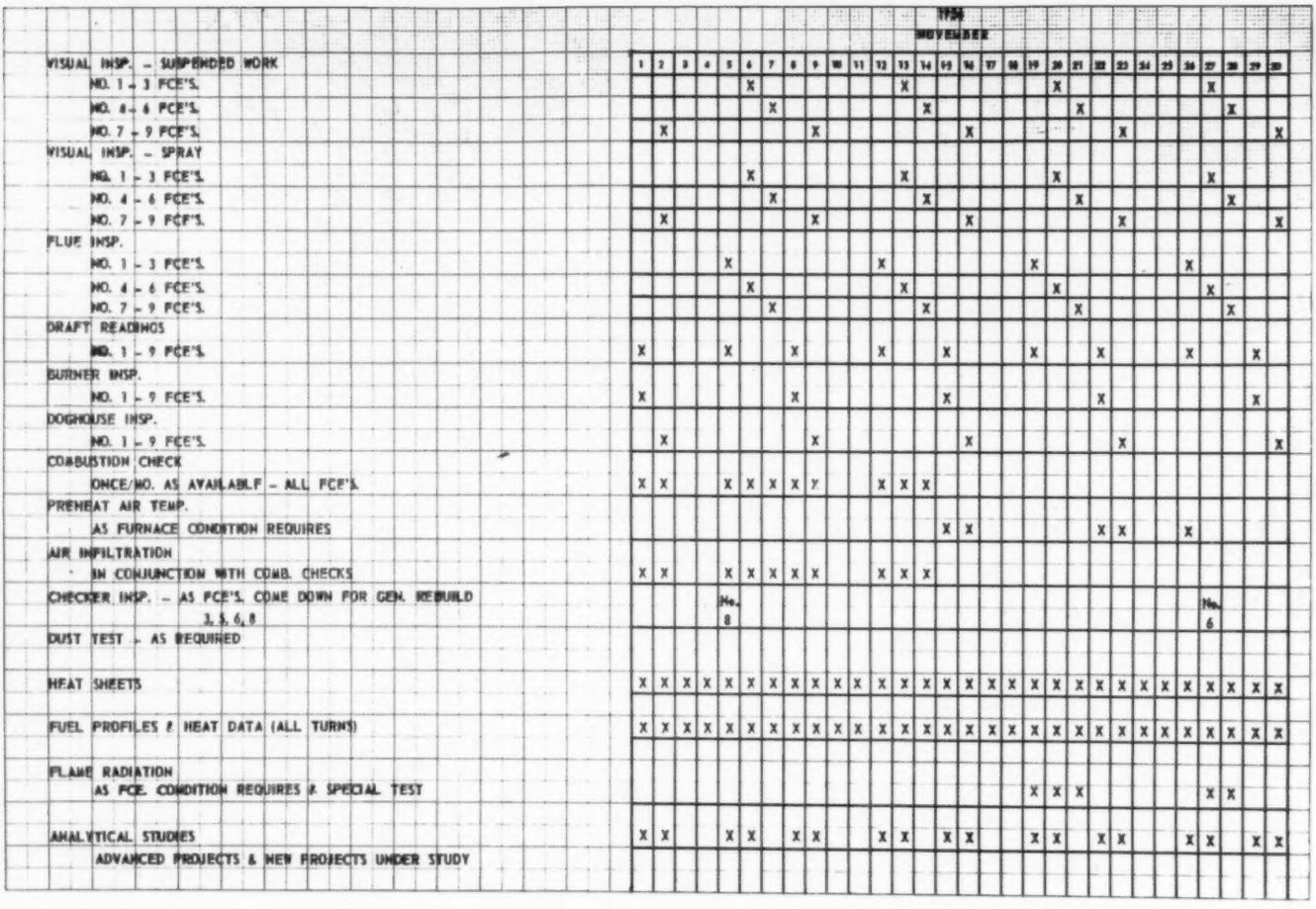
Of these, only the first five are normally varied by the first helper during a single heat. A tenth variable, which is not entirely under the control of the operator on a single heat, is the combustion air temperature. This is, of course, affected by reducing atmospheres in the checkers, temporary high rate of air delivery, checker cleaning programs, furnace design, variations in rate of fuel input, position in campaign, type of refractory used in the checkers, etc. In short, air temperature differs from the other variables in that it cannot be controlled by a knob at the panelboard, but it is the result, from a given furnace, of how well the combustion process and maintenance programs have been carried out.

Combustion variables have been studied on a ½ scale model of a furnace, trying to simulate the working period. These experiments have been extremely helpful. It is possible to isolate independent variables and study them in relation to others and thus observe the magnitude of the effect of the change. This is not readily possible in commercial furnaces.

The significant variables, after much experimentation and field study, were found to be fuel rate, air rate, oxygen in waste gases, air temperature, roof temperature, furnace pressure, air infiltration and, to a lesser degree, steam-fuel ratio. All of these, with the exception of air infiltration, are now being measured on one or all the furnaces. Work is now under way on a method of recording air infiltration. The other variables, as long as they are kept within limits that pre-

**Figure 6 — View of waste heat boiler and its control panel.**

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NO. 1 – 3 FCE'S.
NO. 4 – 6 FCE'S.
NO. 7 – 9 FCE'S.
FLUE INSP.
NO. 1 – 3 FCE'S.
NO. 4 – 6 FCE'S.
NO. 7 – 9 FCE'S.
DRAFT READINGS
NO. 1 – 9 FCE'S.
BURNER INSP.
NO. 1 – 9 FCE'S.
DOGHOUSE INSP.
NO. 1 – 9 FCE'S.
COMBUSTION CHECK
ONCE/MO. AS AVAILABLE – ALL FCE'S.
PREHEAT AIR TEMP.
AS FURNACE CONDITION REQUIRES
AIR INFILTRATION
IN CONJUNCTION WITH COMB. CHECKS
CHECKER INSP. – AS FCE'S. COME DOWN FOR GEN. REBUILD
3, 5, 6, 8
No. 8
No. 6
DUST TEST – AS REQUIRED
HEAT SHEETS
FUEL PROFILES & HEAT DATA (ALL TURNS)
FLAME RADIATION
AS FCE. CONDITION REQUIRES & SPECIAL TEST
ANALYTICAL STUDIES
ADVANCED PROJECTS & NEW PROJECTS UNDER STUDY

**Figure 7 — Chart shows a monthly schedule for various tests.**

vent mechanical damage to the furnace, do not appreciably affect furnace performance.

The open hearth test program performed by the fuels group is necessary to realize maximum efficiency from existing equipment. The intensity of our program becomes more pronounced as the furnaces progress through their campaigns. The test program is the primary function of the analyst group, and special emphasis is placed on analytical studies to improve open hearth production.

Periodic tests are performed on a routine basis, to study those conditions of the furnace that vary either with age or furnace operation. These tests (Figure 7) consist of the following: visual inspection for leakage, burner inspection, draft reading throughout the system, doghouse inspection, correlating open hearth checker washing programs and checker inspections to our periodic draft readings, flue inspection throughout the system when a furnace is down, and under the hot pass while the furnace is operating. This is done to correlate furnace operation with checker washing and the flue blowing program. To eliminate combustibles in the furnace system, continual inspections are made of all utilities distribution systems and combustion

**Figure 8 — Typical firing profile for a heat with good furnace performance.**

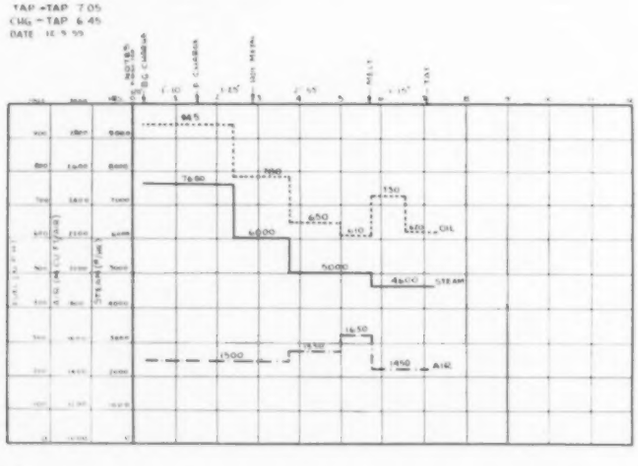
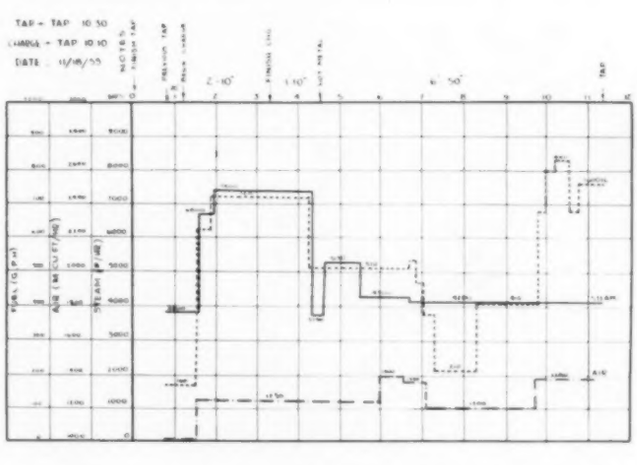


**Figure 9 — Typical firing profile for a heat with poor furnace performance.**



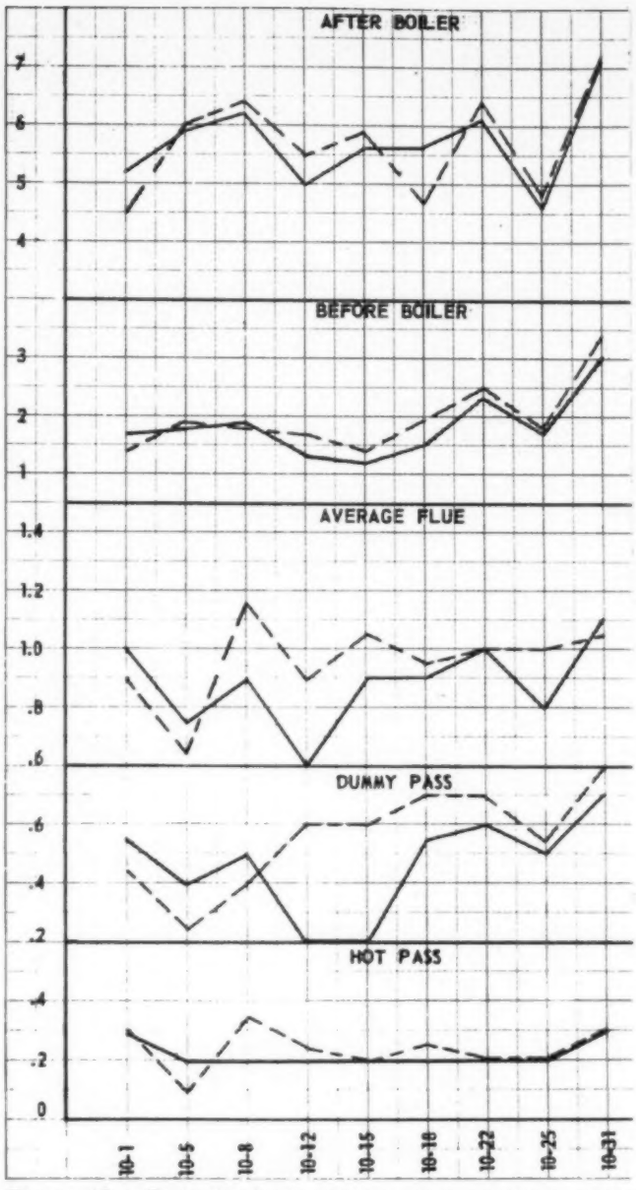



**Figure 10 — Periodic draft readings from various points in the furnace are plotted to spot trouble. Solid lines show north end of furnace; dotted lines, south end.**

testing is done on a periodic basis to establish an air requirement schedule for the recommended fuels and steam rates established on all furnaces. It is felt that an excess air program (assuring no combustibles) is of value to improve refractory life without any appreciable effect on preheat air temperature.

A typical fuel, air and steam profile for a good and poor heat are shown in Figures 8 and 9. These examples are used periodically to train the first helpers and constantly remind them that the controls can provide good furnace performance and fuel efficiency simultaneously. In fact, if the combustion process is not carried out efficiently, it is almost impossible to effect a successful heat time except on a very short time basis and this will surely affect refractory life. In an effort to control our fuel consumption, fuel profiles showing fuel and steam usage and heat data are recorded. These are used by the fuels group and the open hearth personnel for information and control. These profiles have contributed greatly to a uniform firing practice for the shop and to efficient utilization of available fuel. They are a means of evaluating part of our contribution to the fuel program.

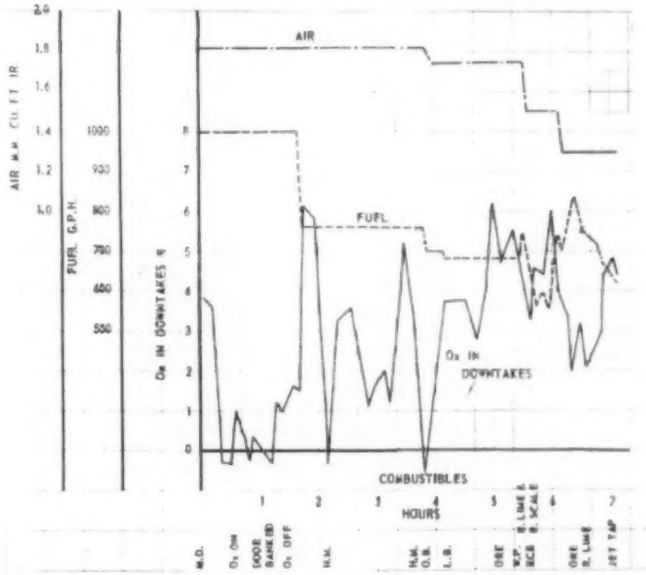
Air infiltration is probably the greatest contributor to poor fuel and furnace efficiency. For this reason, a great deal of time and effort is spent by the fuels group in attempting to reduce it to a practical minimum.

Furnace pressure is the primary factor in infiltration across the furnace proper. Air which enters above and after the checker system is most detrimental to air preheat and flame temperature. Assuming the brick work is tight, furnace pressure is maintained throughout the heat as high as furnace conditions dictate. During meltdown a furnace pressure of 0.10 in. $H_2O$ is maintained and 0.08 in. $H_2O$ throughout the remainder of the heat. Periodic draft readings (Figure 10) are taken and plotted to show blockages in the system and to aid in determining the work necessary on a rebuild.

In the uptake and regenerative system, infiltration is also of concern. To control this infiltration, visual inspections are made periodically of the suspended work, the checker bulkheads, and roof. The results of these inspections are recorded on standard forms and distributed to the open hearth personnel and the masonry superintendent. Upon completion of necessary repairs and sealing, these forms are checked off and returned to the fuels group for filing. To determine the degree of infiltration in the furnace system, checks are made with a portable oxygen analyzer showing the oxygen pickup from the beginning of the downtake to the entry of the flues. Gas volume measurements are taken periodically for correlation with the infiltration checks. With standard conditions in the furnace and a uniform method of calculation, repeatability is possible from furnace to furnace, so that a shop-wide comparison can be made. Average checker temperatures in the work period are plotted against heat time for all furnaces in an attempt to correlate checker temperature and condition with heat time and to obtain a characteristic curve for the individual furnace.

Air preheat temperature is in effect another method of determining air infiltration and the ability of the regenerative system to recover Btu from the exhaust

**Figure 11 — Oxygen analyzers are useful in checking furnace performance.**



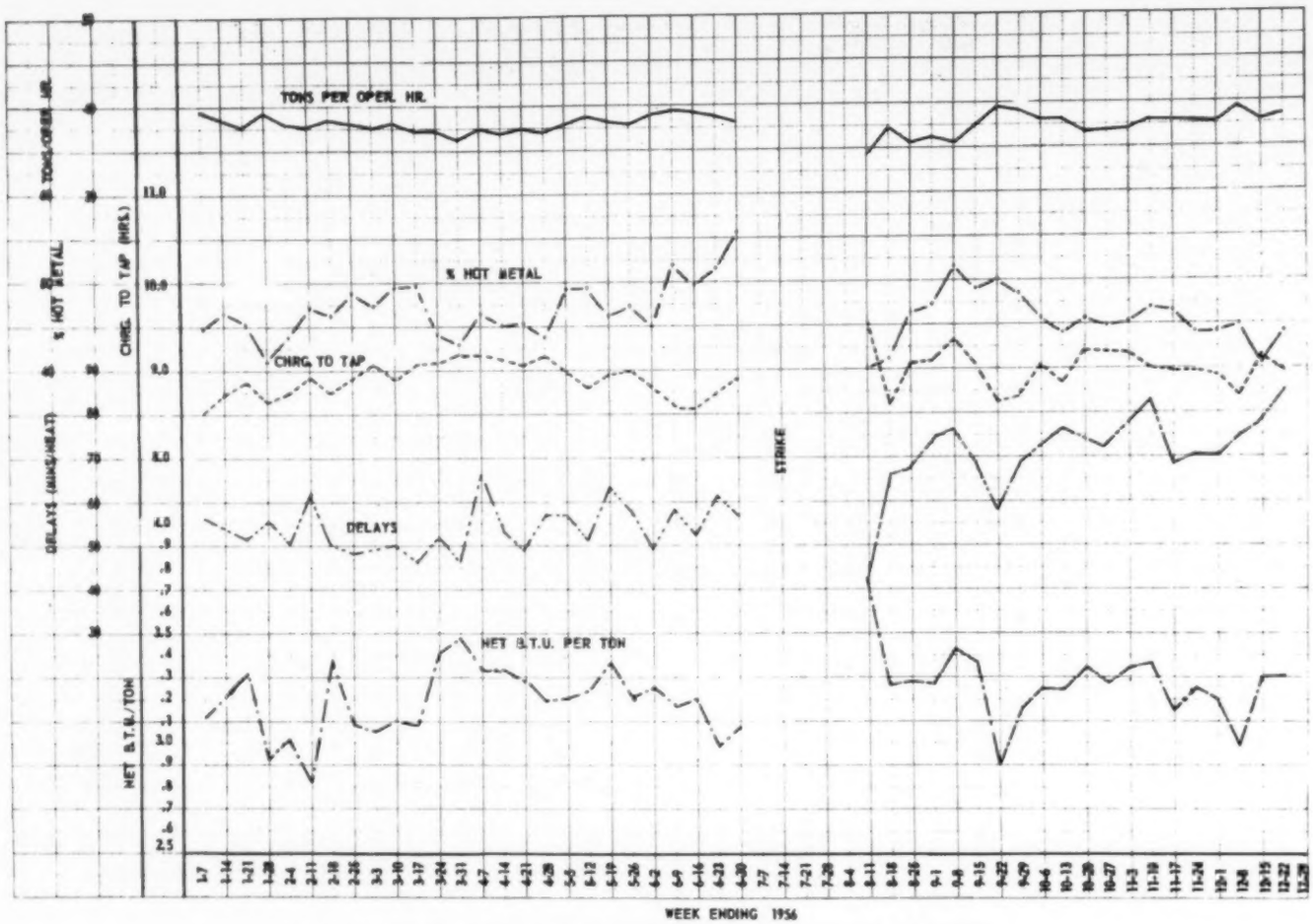
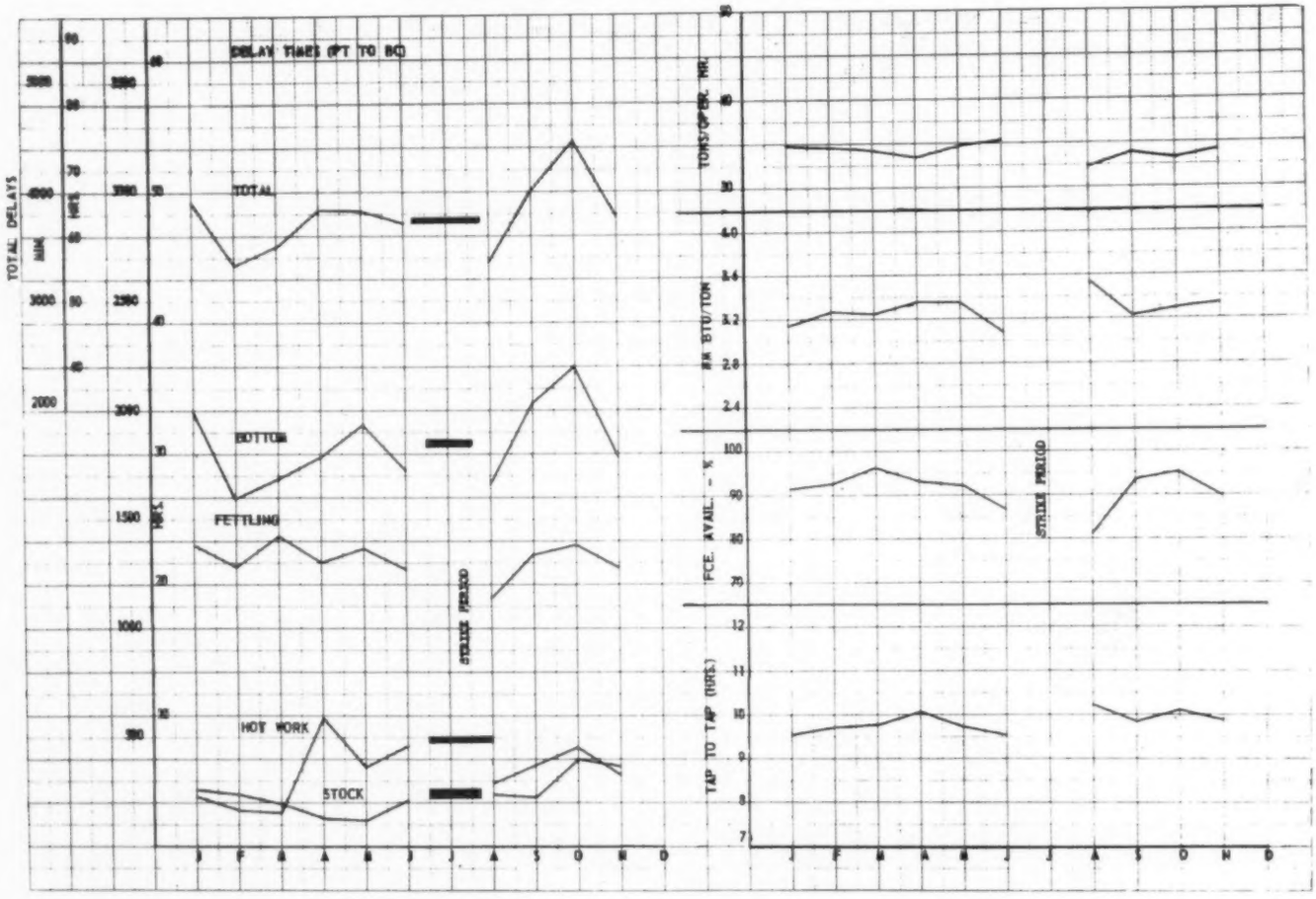



Figure 12 — Shop averages of some variables in furnace performance.

Figure 13 — Shop averages of furnace delays.



gases and release them to the incoming combustion air. Preheated air temperatures are taken periodically during the life of a furnace checker system.

Waste heat boiler steam production is a measure of furnace efficiency. High steam production is normally a result of over-firing or high exhaust gas volume. Steam production by furnace is plotted daily, giving a trend-type curve and fuel utilization picture for the individual furnace, as well as a production level comparison from furnace to furnace. Exhaust gases leaving the waste heat boiler pass through precipitators for dust recovery before entering the stack. Dust tests are run periodically to determine precipitator efficiency and outlet loading.

As the present equipment reaches its expected design limit, special tests are required to obtain greater efficiency for a part or all of the system. Special testing is also carried out in conjunction with our analytical studies to make recommendations which will increase productivity. Some of these special tests include flame radiation, preheated air temperature, air infiltration studies, dust tests, exhaust gas volume studies, etc.

It must be stressed that the effectiveness of our test program is only as good as the measures taken to remedy the conditions that are found, and it must be sold to the operating personnel to gain their cooperation of interest. At Fairless, the fuels group is in a position of having an open hearth group that is increasingly anxious to use the services that can be provided.

The normal test program supplies much of the data for continuous graphic exhibits for analytical studies and correlation of furnace variables. In order to use available data for analytical study, means must be found to control and record the combustion elements that have previously been obtained by periodic tests.

One example of this effort involves continuous oxygen analyzers that were installed on several furnaces. The analysis of excess air in the gases entering the downtake serves many purposes. The analyzers are presently independent of the control system. Tests (Figure 11) have been run over a short period of time to determine their flexibility, accuracy, response and ease of maintenance. These tests have resulted in plans to tie one of the analyzers into the combustion air control. The addition of a combustibles indicator will complete the optimum control system for combustion air; however, as indicated in Figure 11, it is not practical to have a direct ratio control dependent on the oxygen analysis.

In addition to eliminating reducing atmospheres in the regenerative system, and assuring complete combustion with minimum excess air, the analyzer will free man-hours to be devoted to analytical studies.

Recently, an industriai type television camera with separate receiver has been successfully installed in the port-end wall of a furnace, giving full view of the complete furnace interior from bath to roof, front wall to back wall. This allows visual observation of effects of steam-fuel ratios, furnace pressure, charging practice, immersion couple practice, bath action, burner elevation and alignment, etc.

The realization that these basic elements of combustion control are not only variables, but are controlled to an extent by other variables, known and unknown, emphasized the need for conclusive analytical studies leading to improved operation and better automatic control systems.

Pictorial analyses in the form of continual graphic recordings are perhaps as much of an aid to the fuels group as they are to the open hearth personnel. Graphs are kept on each furnace on an appropriate time basis. Continual recording gives trend-type curves for each

**Figure 14 — Heat-by-heat record of times for various periods of the heat for an individual furnace.**

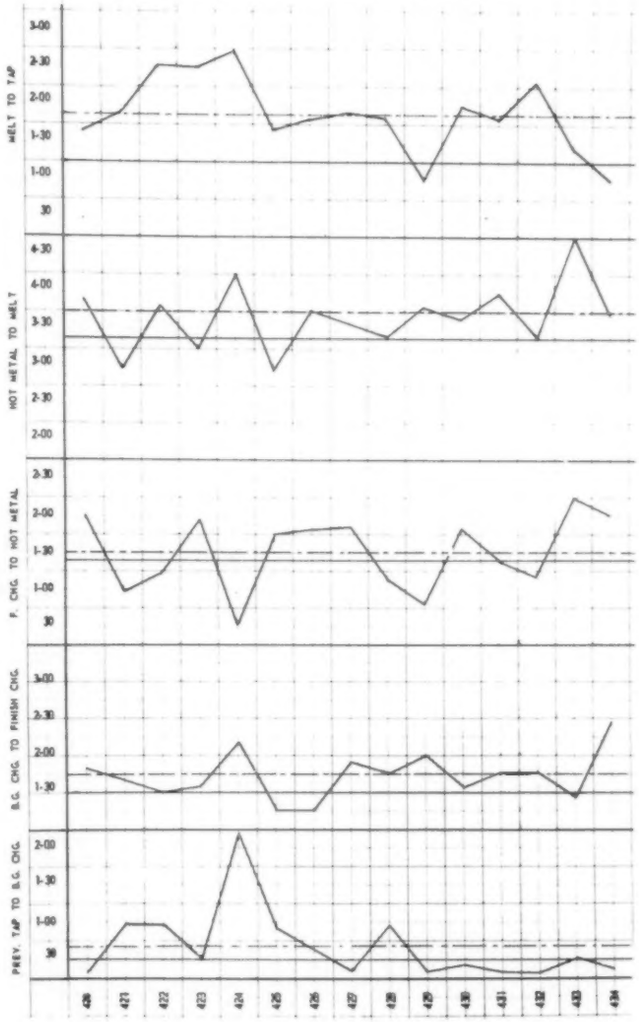
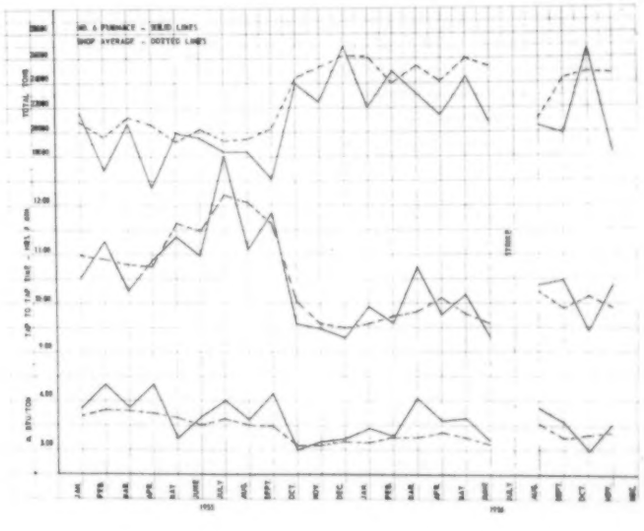



**Figure 15 — Chart shows an individual furnace performance compared to shop average.**



furnace as well as a comparison of furnaces.

A few examples of the type of trend data plotted on a continuous basis are shown in Figures 12, 13, 14 and 15.

Curves of this nature help to evaluate past performance and to supply a means of control for present performance with respect to the shop trend. These curves provide the fuels group with a measuring device to determine improvement of a furnace or the need for improving a furnace. The pin-pointing of trouble in a furnace is one of their objectives.

Although many factors effect the open hearth process, some recorded and others that cannot be recorded, it is possible to project the effects of these factors into the immediate future. Several analyses of furnace variables, accomplished with the assistance of the applied research group, have allowed us to predict some of those effects with reasonable success.

Curves that are recorded are mainly those variables to which the fuels group directly or indirectly contribute, and those that affect heat time to gain tons at the best possible cost per ton. The curves can be assumed to serve five functions:

1. Daily or weekly control type curves which help pin-point factors affecting furnace efficiency and production.
2. Information and consumption curves which show the rate of increase or decrease of the major production quantities.
3. Monthly and periodic curves which give a long range picture of the effect on production resulting from the many variables that are continually being checked and controlled where possible.
4. Short term unit curves that deal with a specific furnace or variable being subjected to other than normal usage for the purpose of evaluation.
5. Curves kept only for the period of time necessary to prove or disprove the relationship of the variable or variables under study to a known condition.

The end result of analytical studies is to determine the relative effects of the many variables of furnace life and steel production.

## "INCREASING OPEN HEARTH CAPACITY BY EXTENDING THE HEARTH"

By

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Lukens Steel Co.,

Coatesville, Pa.

▲THE purpose of extending a furnace hearth is, of course, to obtain additional capacity from the furnace. This increased capacity is the result of several basic advantages, namely:

1. More of the bath area is exposed to the flame.
2. If the original heat size is maintained, the depth of the bath will be reduced, and the heat from the flame will have less depth of metal to penetrate.
3. With more of the bath exposed to the flame, and less depth of metal to be penetrated, the bath can absorb heat at a greater rate. This will result in faster heat time.
4. If, however, the original bath depth is maintained, the extended hearth will increase the bath volume and heat size without requiring the flame to penetrate a deeper bath. With this condition, the furnace can process a larger heat with very little, if any, increase in process time.
5. The sloped portion of the hearth above the chill will be farther away from No. 1 and No. 5 doors, allowing more clearance to turn the empty charging boxes containing large scrap. This will aid in reducing the charging time.

In No. 3 shop at Lukens the hearth on No. 22 furnace has been extended. This paper gives a brief report of the installation, along with the progressive achievements made on this particular furnace.

Figure 1 sectional evaluation and plane of the original 75-ton capacity No. 22 furnace, built about 1917. The 17 ft 3 in. distance from the endwall of the furnace to the bath was required to allow for the turning and imparting of direction to the producer gas stream, and to the obvious fact that the chills had to be located to clear the sloping air uptake flues. This furnace had a 35 ft bath length.

Figure 2 shows No. 22 furnace, now rated at 135 tons, just prior to the hearth extension in 1956. Some improvements since 1917 include:

1. The triangular chills have been relocated to provide a 38 ft-10-in. bath length.
2. The 15 ft-4-in. distance from the furnace endwall to the bath. This distance was 17 ft-3 in. on the original furnace.
3. The double uptake and dog house type construction with uptake areas of 33 sq ft.

One of the reasons No. 22 furnace was selected for an extended hearth was that it had basic suspended port end construction, installed in 1952.

At this point, it might be of interest to note the fact that chill wall, fantail nose and checker wall suspensions are almost always required to properly reconstruct a furnace with maximum hearth length. The reason for this is that interference develops between the skewback support for the sprung chill arches and fantail arches. Since no adjustment in chill elevations can be made, the only way to avoid this interference is to lower the fantail arches. This often restricts fantail area, and increases the velocity of the gases, causing extreme wear, an undesirable condition in this critical area. By suspending the chill wall and fantail nose, this interference problem is eliminated, since sprung chill arch thrust is no longer a consideration.

Figure 3 shows the new extended hearth installed in April, 1956. The triangular chill boxes have been removed. In their place, is a chill made of sloping plates backed-up with stiffening beams. These beams are connected to the extended side pan plates. The top chill beams are connected to the sidewall buck-stays. This allows a bath length of 46 ft-10 in.

With double uptake and dog house type construction, the 11 ft-4-in. distance from the furnace endwall to the bath was too short to permit proper mixing of

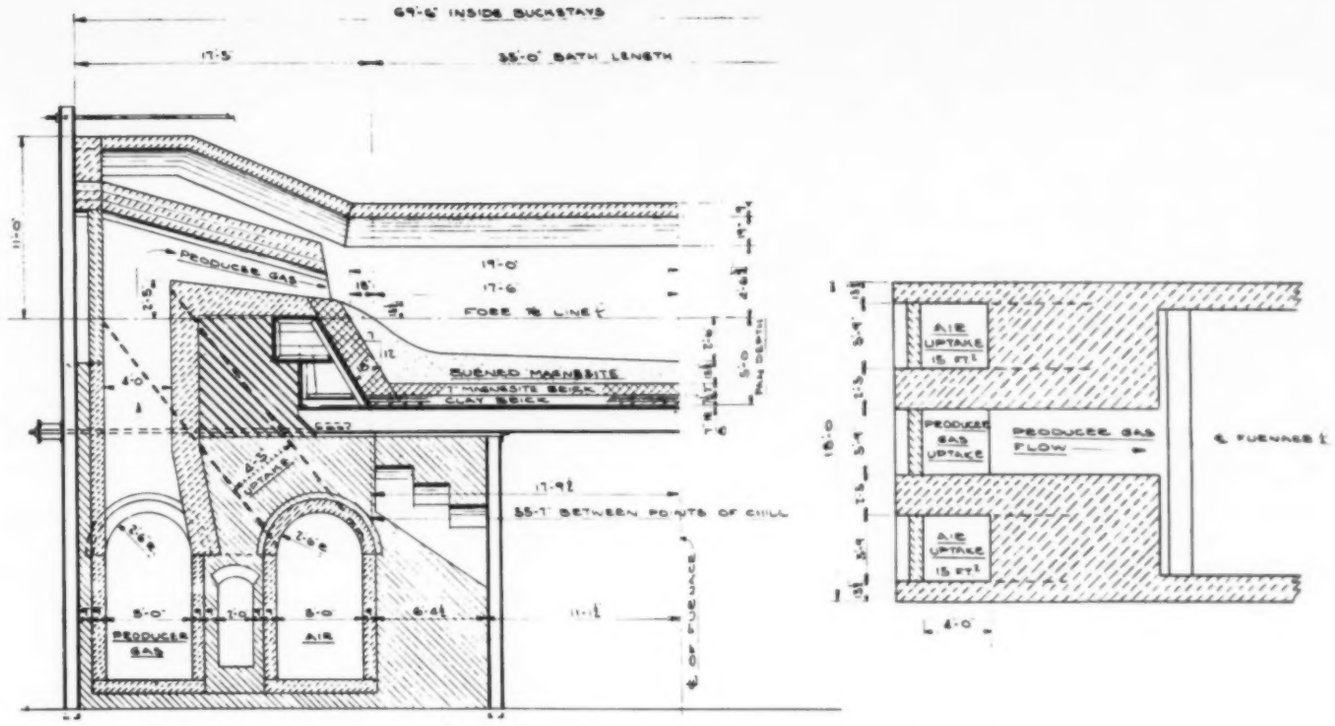



**Figure 1 — No. 22 furnace was originally built in 1917 as a 75-ton unit to these dimensions.**

combustion air and fuel. Therefore, artillery type burners and single uptakes were used.

Because corner burners are used as an aid in scrap melt-down, the peak fuel rates are quite high. Therefore, it was decided not to further restrict the uptake area, as many other shops have done with single uptake type construction.

The single uptakes were made 2 ft-10⅜ in. × 11 ft, giving us an area of about 31.5 sq ft each, as compared to 33 sq ft for the old double uptakes.

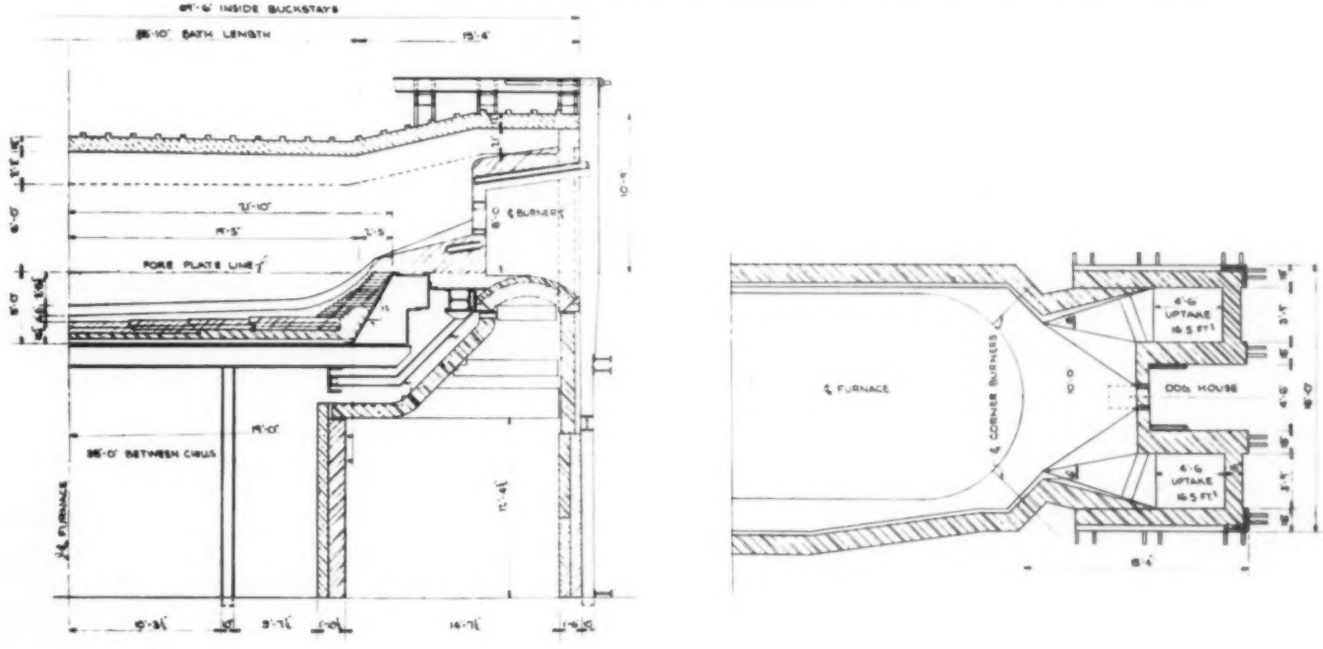
Basic brick arches were run out 2 ft from the sidewalls to support the corbelled brickwork required to obtain an 11-ft uptake in a 15-ft wide furnace. Very little additional chill wall suspension was required to cut down the uptake from 4 ft-6 in. to 2 ft-10⅜ in.

Figure 4 shows the final ramming of the plastic chrome ore on the portion of the hearth above the chills that has been replaced. This portion can easily be recognized by the difference in color.

The artillery type burner (not yet adjusted) is shown in the endwall of the furnace. The corner burners appear, also.

Figure 5 is a view of the furnace backwall, showing the extended side pan plate from the outside of the furnace (white outline). A gain of 4 ft-1 in. was obtained in hearth length at the fore plate level. The bolt

**Figure 2 — The furnace had been redesigned to these dimensions for liquid fuel and 135-ton capacity.**



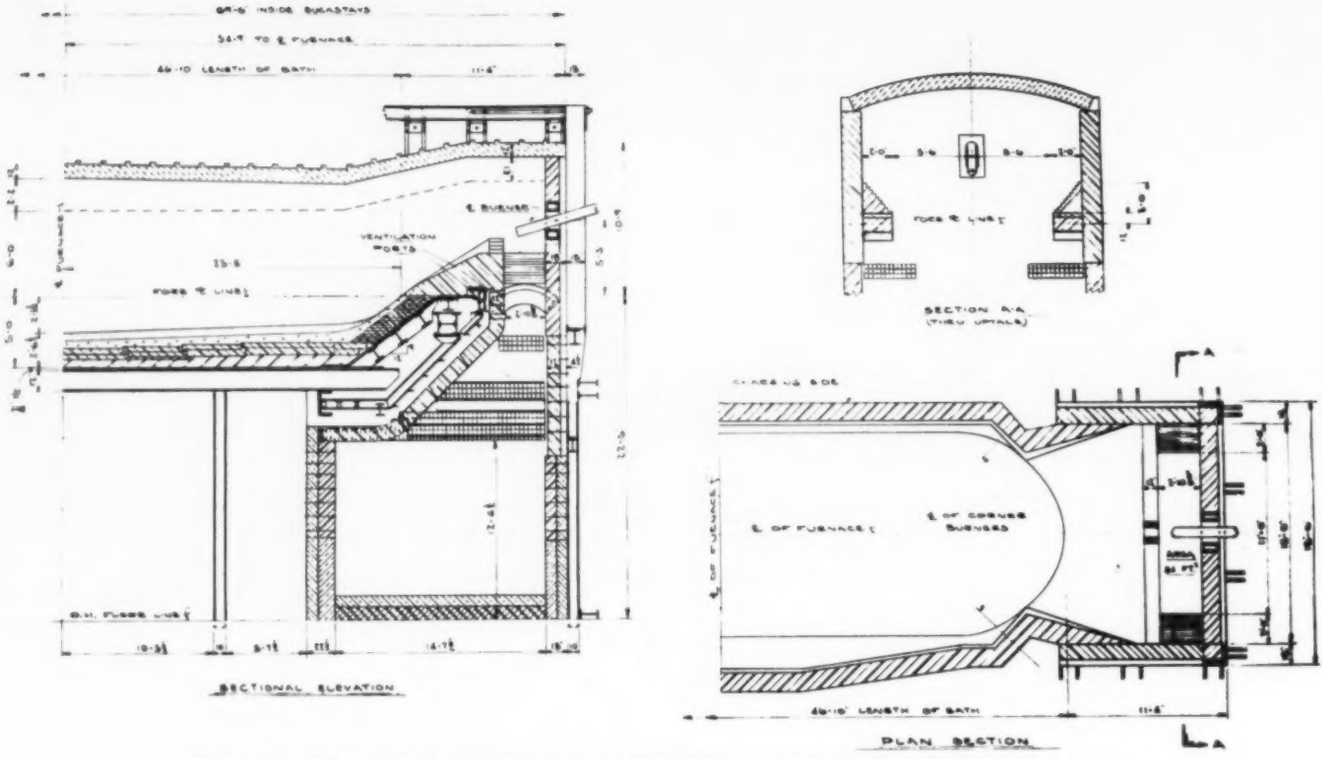



**Figure 3 — This sketch shows details of No. 22 furnace after the hearth was extended.**

heads of the 12-in. flange stiffening beams, used to back up the sloped pan plates, may be seen below the solid line.

Figure 6 is a view of the suspension support beams that are connected to the sidewall buckstays. There are ventilation ports on both sides of the support beams. These ports extend across the furnace. The 12-in. suspended basic brick does not insulate the steelwork adequately without air circulation. Some shops have had suspension support beams sag due to excessive heat, a result of insufficient ventilation.

Figure 7 compares the progressive hearth extensions of No. 22 furnace, showing the successive bath length extensions of 23 ft and 4 ft, the chill length extensions of 14½ in. and 4 ft-1 in., and the variations of uptake lengths and areas. All these extensions were made without increasing the distance between buckstays.

Table I shows a comparison of hearth data before and after the extension. The increases in bath length, volume and area are apparent. When operating the furnace with a 135-ton heat, the bath depth will be 26½ in., or 2½ in. below the normal 29-in. depth maintained before the extension.

With the open hearth pit building just about stressed to the limit, and the ladle cranes operating at their maximum rating, tapping of 30 tons of added furnace capacity became a problem. A study was made to determine weight reduction possibilities in the ladle and crane hook lift beam assembly.

The 135-ton ladles in service had cast steel bales and were designed with little regard to weight considerations. Consultation with ladle builders disclosed the fact that, by going to a welded ladle shell with hollow cast steel channel sections replacing the usual solid plate ribs, a 150-ton ladle shell would weigh 11,000 lb less than the prevailing ladle shell of 135-ton capacity.

Figure 8 compares the two ladles, showing the cast steel trunion ring, the heavy trunion castings and the riveted vertical splice plates on the 135-ton ladle. The hollow cast steel channel sections and the vertical structural channels on the new 150-ton ladle are also illustrated. With a ring added to the top, 165-ton heats could readily be tapped with this new ladle. The new ladle is 15,000 to 18,000 lb lighter than a comparable standard design ladle. It was developed without

**Figure 4 — Interior of furnace shows main burner and corner burners.**

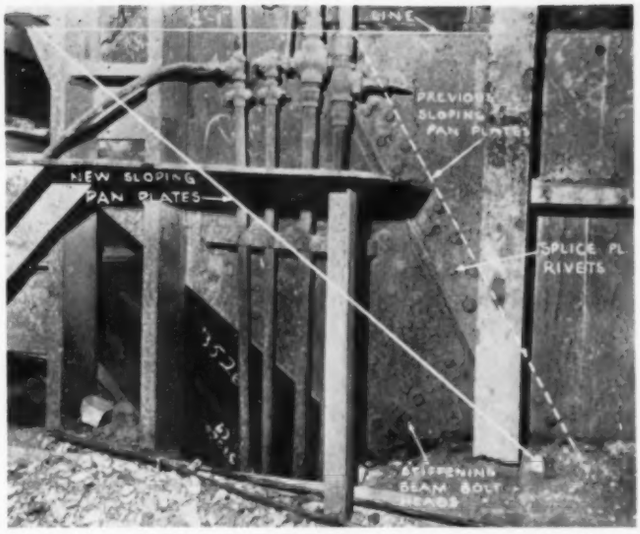



**Figure 5 — White outline indicates the lines of the old and new sloping pan plates.**

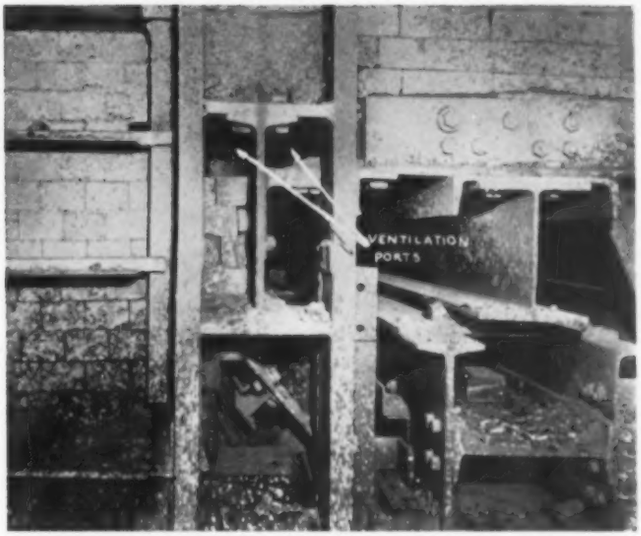



**Figure 6 — Ventilation of the suspension support beams is essential to eliminate the possibility of their sagging.**

raising stresses appreciably, or using alloy materials.

Since the existing lift beam would not allow sufficient clearance for rotation of the new elliptical ladle, a new lift beam was required. A new welded plate lift beam was designed that would provide ample rigidity, with a 1600-lb reduction in weight. Each 75-ton hook was redesigned for 100 tons, and made of high tensile "T-1" steel, with a weight reduction of 700 lb per hook. This resulted in a reduction of 3000 lb on the crane hook and spreader assembly.

Table II summarizes the weight reduction of 16,000 lb in the ladle and crane hook assembly. An 8-ton increase in heat size is possible without any additional load on the crane or building.

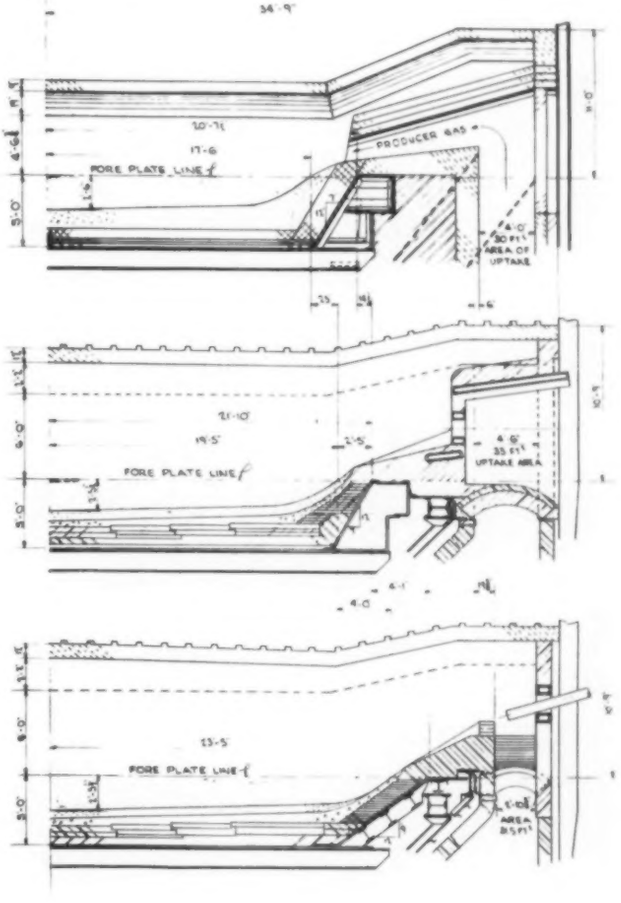
Since the new light weight equipment was not immediately available, the increase in heat size had to be limited to six tons, tapped in the existing ladles with linings reduced from 8 in. to 6½ in. Table III is a production study of the first campaign on No. 22 furnace after lengthening the hearth. As anticipated, with a 6-ton increase in heat size, a 16-minute reduction in heat time was realized. This provided an increase of 0.8 tons per hour with a 0.6 gallon per ton reduction in fuel. It is interesting to note that this increase in production was obtained with conditions as nearly normal as possible. The iron charge was 30 per cent, which is normal for the shop. It should be noted that the shop average tons per hour for a three month period prior to the first campaign was 9.68, whereas No. 22 furnace operated at 10.53 tons per hour.

During the first campaign with the extended hearth, No. 22 furnace had about 32 special heats—that is, heats requiring from one to three hours above normal heat time. During the second campaign, No. 22 handled 50 such heats, an increase of 60 per cent over the first campaign. This condition affected the production gains to some extent.

In Table IV, summarizing the second campaign on No. 22 furnace, the charge to tap time shows no improvement over the shop average and is 12 minutes longer than in the campaign prior to the extension. This is partially due to the effect of the large percentage of special heats. With a 5000-lb greater charge weight, No. 22 furnace was 2.7 tons per heat and 0.51 tons per hour ahead of the shop average for the campaign.

The extended hearth furnace at Lukens has not been in service long enough to fully establish production figures. We are convinced, however, that with a 6-ton increase in heat size the 16-minute reduction in charge to tap time, with some reduction in fuel already ex-

**Figure 7 — These sketches compare the successive steps of elongation of the furnace hearth. At the top is the original 75-ton furnace. At center is the design of the first enlargement. The bottom sketch shows the latest extension.**



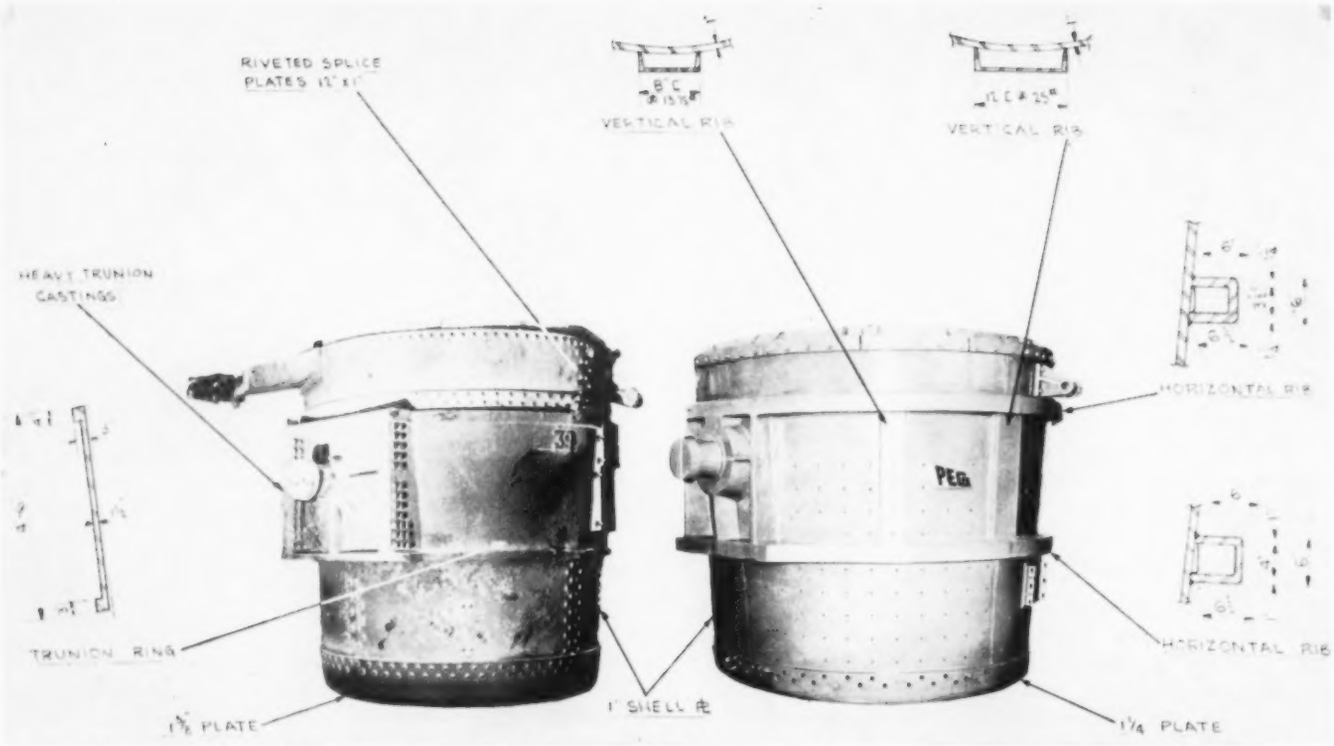



**Figure 8 — Comparison of ladle designs. At the left is the old 135-ton ladle, with a shell weight of 49,200 lb. At the right is the new 150-ton elliptical ladle, with shell weight of 38,200 lb.**

**TABLE I**
**Hearth Comparisons—No. 22 Furnace**

| | Bath length, ft-in. | Bath volume, cu ft | Capacity, ingot tons | Bath area, sq ft | Bath, depth of metal, in. |
|---|---|---|---|---|---|
| Prior to hearth extension | 38-10 | 665 | 135 | 501 | 29 |
| With extended hearth | 46-10 | 813 | 165** | 613 | 29* |
| Increase | 8- 0 | 148 (22.4 per cent) | 30 | 112 (22.4 per cent) | |

* 26½ in. for 135-ton heats.
** Potential tonnage—The present pit buildings, cranes and ladles do not allow full utilization of this additional capacity.

**TABLE II**
**Weight Reduction Tabulation**

| | Ladle | | Hook and spreader assembly | |
|---|---|---|---|---|
| | Weight of shell, lb | Weight of refractory lining, lb | Weight of hook and spreader assembly | |
| Present 135-ton ladle | 49,200 | 39,600 (8 in. thick) | With original 150-ton hooks | 23,400 |
| New design 150-ton ladle | 38,200 | 37,600 (6½ in. thick) | New 200-ton high tensile hooks | 20,400 |
| Weight reduction | 11,000 | 2,000 | .... | 3,000 |
| Total weight reduction | | | | 16,000 lb |

**TABLE III**
**Production Study—First Campaign**
**August 10, 1956**

| | Number of heats | Charge to tap time, hr | Average ingot tons per heat | Tons per hour | Gallons per ton |
|---|---|---|---|---|---|
| Campaign prior to hearth extension | 166 | 12.89 | 133.8 | 9.73 | 40.5* |
| First campaign with extended hearth | 147 | 12.62 | 139.8 | 10.53 | 39.9 |
| Change | ... | 0.27 (16 minutes) | +6 | +0.80 (9.68)** | −0.6 |

* Shop average for same period.
** Shop average prior to first campaign.

**TABLE IV**
**Production Study—Second Campaign**
**November 12, 1956**

| | Number of heats | Charge to tap time, hr | Average ingot tons per heat | Tons per hour | Gallons per ton |
|---|---|---|---|---|---|
| Campaign prior to hearth extension | 166 | 12.89 | 133.8 | 9.73 | ... |
| Second campaign with extended hearth | 155 | 13.09 | 138 | 9.9 | 40.9 |
| Change | ... | +0.20 (12 minutes) | +4.2 | +0.17 | +0.4 |
| Shop average for period of second campaign | ... | 13.08 | 135.3 | 9.39 | 40.5 |

perienced in the first campaign, can be consistently maintained under normal operating conditions.

In February, 1957, the first heat was tapped into the new ladles and teemed with the new lift beam assembly.

A light weight ladle crane trolley to provide further weight reduction, along with a building reinforcing project, could result in utilization of most of the remaining potential furnace capacity at any future time.

Lukens has completed plans for another hearth extension and will, no doubt, consider future installations.

## "INCREASING THE CAPACITY OF AN OPEN HEARTH SHOP"

By

M. K. MORRIS

Assistant Superintendent

No. 2 and No. 4 Open Hearth Shops

Bethlehem Steel Co.

Bethlehem, Pa.

▲ WITH the decision to increase the rolling and shipping facilities at the Saucon Division of the Bethlehem Plant, it became necessary to increase the ingot capacity of the divisions No. 2 and 4 open hearths. To accomplish this it was decided, after much study, to increase the capacity of the sixteen 130-ton furnaces at No. 2 open hearth to tap 160-ton heats.

Before going into the program of increasing the capacity of No. 2 open hearth, it should be noted that No. 4 open hearth is a five-furnace shop tapping heats averaging 235 tons. Directly west of this shop is the hot metal mixer building and to the west of this is No. 2 open hearth shop.

A survey was made of No. 2 shop and its auxiliary facilities to determine what was needed to obtain the increased tonnage. From this survey the following schedule was developed:

*Building*—Inspect and repair all structural joints in the building.

*Furnaces*—Increase the bath depth by 3 in. To take care of the higher fuel input, 14 new combustion air fans of increased capacity were needed.

*Pit Section*—Extend the ladles by 24 in. and deepen the ladle lining pit. Add two new 160-ton ladles. Replace the 150-ton pit crane with 200-ton unit.

*Stripper building*—Extend the stripper runway 30 ft. Replace the 100-ton stripper crane with a 200-ton unit.

*Mold yard section*—Extend the mold yard by six bays, with the necessary changes in track layout. Add two 20-ton cranes to the runway. Extend the mold coating platform and add another water dipping tank for molds.

*Charging floor section*—Install a 60-ton crane. Add four new charging machines. Provide two diesel engines to replace the steam engines used to transport hot metal from the mixer to the open hearth furnaces.

*Stockyard section*—Erect 7-bay extension to the stone and ore bins. Replace the drag-line cable for spotting cars under the bins with an electric 50-ton mine mule. Change the track at the bins to make it possible to put charging buggies under the bins from either end, with necessary tail tracks. Equip the bins with air-operated discharge gates in place instead of the hand-operated levers.

*Mixer-building section*—Replace the 400-ton hot-metal mixer with a new 800-ton unit. Rebuild the 1300-ton hot-metal mixer. Erect a new 100-ton crane at the mixers to take care of the increased amount of hot metal to be handled.

*Narrow-gage section*—Add 48 ingot cars. Add 40 charging buggies with boxes. Add one 100-ton twin-unit narrow-gage diesel engine to handle the additional ingots and molds.

It was also necessary to improve the communications system to take care of the new layout, and to increase the electrical transmission capacity.

The engineering department made a thorough check of the design of the building to determine if it was strong enough to handle the additional load. An extensive check of all structural joints and members was then made by the riggers, and repairs were made wherever necessary.

To increase the bath depth of the open hearth furnaces, the thickness of the sill plates was increased from 5 to 9 in. and the flush holes were raised correspondingly This was done as each furnace was taken out for rebuild.

To supply the combustion air needed to increase the fuel input from 300 to 450 gal of oil per hour was a more time-consuming task. Furnaces 31 through 34 were already equipped with fans of sufficient capacity. On the remaining furnaces, however, new fans had to be installed during rebuilds; in cases where the old fan foundations had to be altered, even longer time

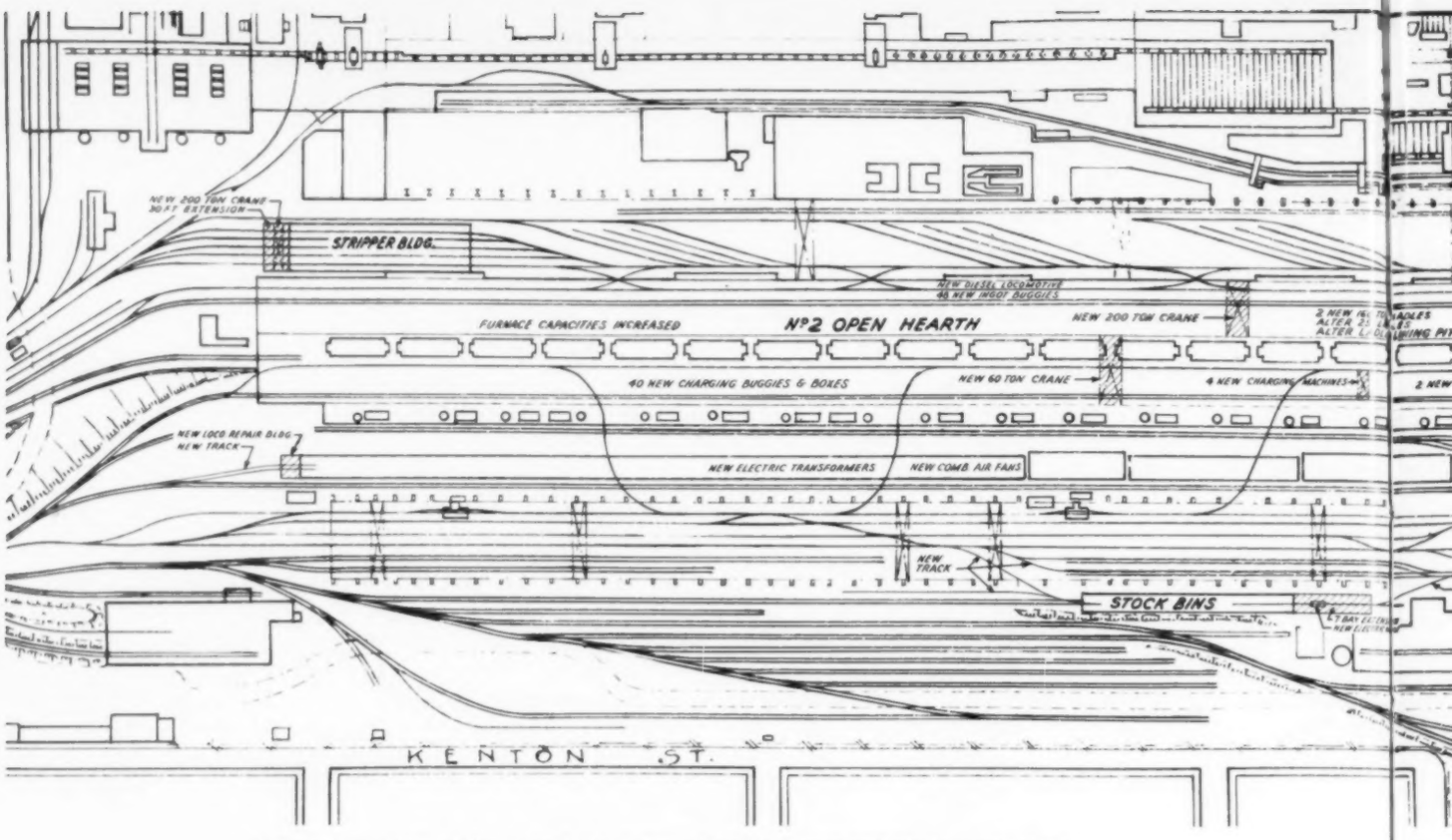



**Figure 1 — Plan of No. 2 and No. 4 open hearth shops and their auxiliaries.**

was needed. During the installation of new foundations, the combustion air was supplied by induced draft.

Extension of the height of the 25 steel ladles by 24 in. was a long drawn-out procedure. First one ladle was sent to the shop for alteration. As soon as the alteration was complete the ladle was sent to be annealed. At the same time, a second ladle was sent to the shop for alteration, and so on, so that the shop always had a ladle on which to work. This meant that the pit section was always two ladles shy, a handicap that was only overcome by very close scheduling with the ladle-lining group and the pit crews. Towards the end of the program the time required for the ladle to be out of the open hearth pits was ten days. Alteration in stopper riggings were made in the field by the maintenance forces. When the first two ladles had been changed over and were ready for service, one furnace was charged with "large" heats, and this progressed until 11 of the 16 furnaces were tapping "large" heats.

Because the 150-ton pit crane could not handle the large heats, it had to be replaced by a 200-ton crane. Five furnaces continued to tap 130-ton heats until the fourth pit crane, a new 200-ton unit, had been erected. The ladles for these five furnaces were not altered because of the possible hazard of lifting the large ladle with the additional weight of slag. When the 200-ton pit crane was erected, the ladle alteration program was resumed and, as the ladles were put in operation, the balance of the furnaces were charged with large heats. The first large heat was tapped on April 6, 1955, and by May 8, 1956, all furnaces were charging large heats.

During the erection of the 200-ton pit crane, the ladle lining station was moved to the west end of the pits; a scaffold for the ladle liners was built above ground. This was necessary because the regular lining station was directly under the erection site of the 200-ton crane.

The lengthening of the stripper-crane runway by 30 ft made it possible to strip the heats of smaller mold size at a single spotting of the cars. This extension was completed prior to the erection of the 200-ton stripper crane which replaced the 100-ton crane. Thus the effective crane runway length was not shortened beyond the original length during the installation of the 200-ton crane.

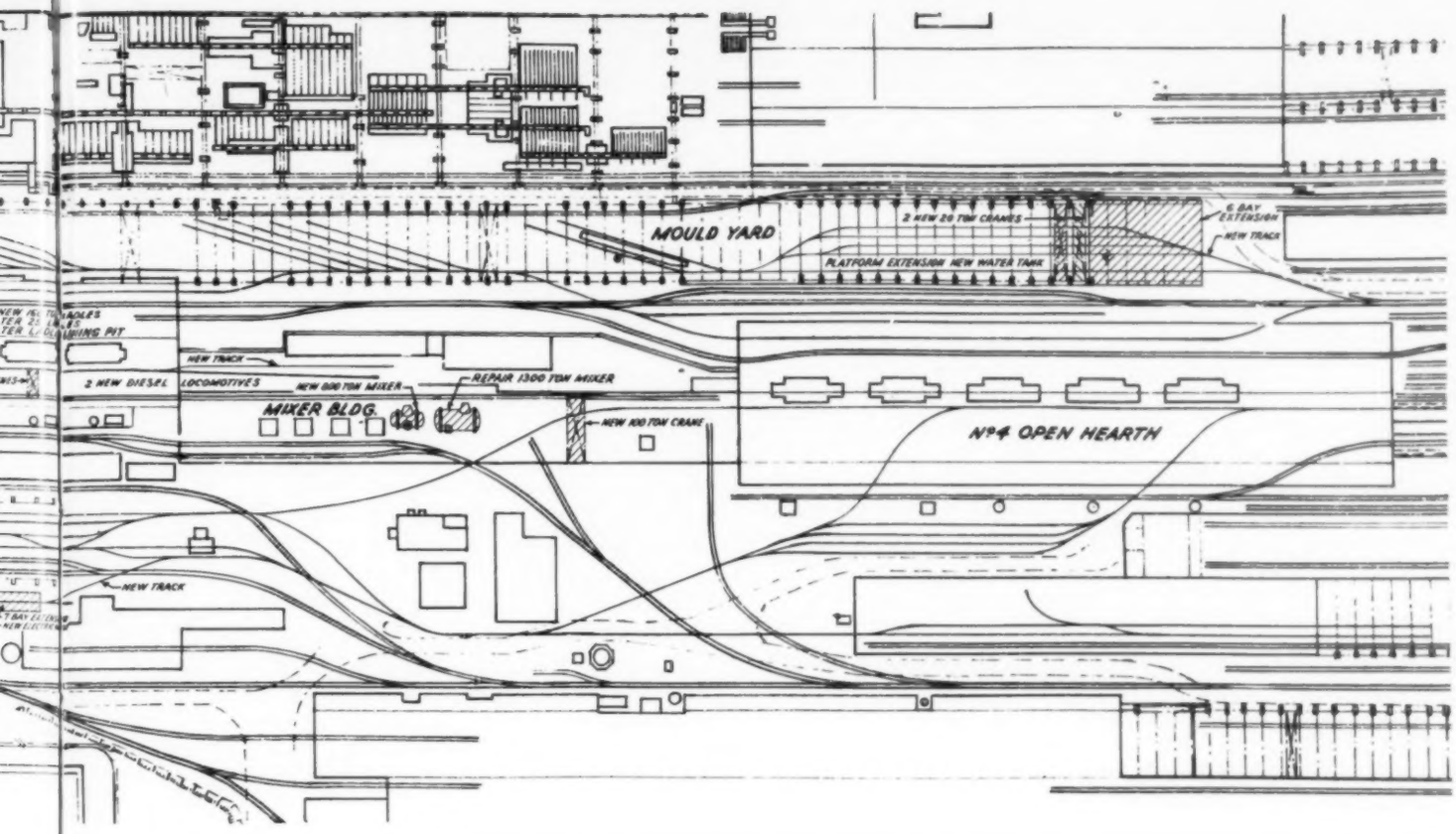
The only severe interference caused by the new crane was the pit required to service the boom. Due to this pit two of the five tracks under the runway were rendered useless.

Extension of the mold yard crane runway by six bays with auxiliaries, changes in the tracks and mold coating platform and the installation of two additional 20-ton cranes were accomplished with minimum interference with the operations.

The additional 60-ton floor crane was also installed and put in service immediately with little interference with operations.

The four new charging machines were installed, one at a time, at the east end of the floor. When a new machine was put in operation an old machine would be dismantled at the west end. Thus, no serious interference with operations was experienced.

The purchase of broad-gage diesel engines for the movement of hot metal was a new venture. The old engines were "thermos bottles" on wheels and were charged several times a shift from a superheated steam line. A repair shop was built at the west end




of the open hearth where these diesel locomotives could be serviced completely except for major overhauling. The big advantage over the old steam engines was the availability which improves the speed of delivery of hot metal to the furnaces.

Where the steamers required charging several times every eight-hour shift, the diesel engines are fueled once every second day. The diesel engine also offers improved visability for the operator, a factor in reducing safety hazards. One diesel is kept as a spare while the other is in service.

The seven-bay extension to the limestone and ore bins will make it easy to handle the increased limestone, iron ore and burnt lime required. This project is not complete and at this writing only the column footings are in place.

The replacement of the drag-line cable with a 50-ton electric mine mule has greatly expedited the loading of limestone, iron ore and burnt lime. The slack in the 1400 ft of cable and in the couplers between the charging cars required real skill to spot the boxes under the discharge of the bins. The electric mine mule eliminates all the cable slack, leaving only the slack in the couplers to overcome.

Installation of air-operated gates did away with the cumbersome old hand levers. The stocking crews are able to obtain more uniform loading because of the positive shutoffs possible with the air gates.

Extensive changes in track lay-out were required at the bins supplying No. 2 and No. 4 open hearth with limestone, iron ore and burnt lime. Originally it was necessary to move all the charging buggies from No. 4 shop to the stockyard at No. 2 shop and then to the bins for loading. This increased congestion in No. 2 stockyard. The new arrangement has eliminated this congestion. It also releases one track for use by No. 2 stockyard that had formerly been reserved for empty buggies going to the bins. A tail track was provided on the west end of the bins, south of the stockyard, to permit loading of the buggies without tailing onto the crossover in the middle of the yard and interfering with other train movements.

A new 800-ton mixer was erected to replace the spare 400-ton mixer, located between the four holes for un-

**Figure 2 — The shell for this 800-ton mixer was assembled at the mixer building and moved by overhead crane to its foundation cradle.**

loading hot metal ladles and the regular 1300-ton mixer. This presented a problem of co-ordination between erection crews and operators. The shell for the 800-ton mixer was assembled and welded on the extreme west of the mixer building. This made it necessary to close one of the four unloading holes. Removal of the 400-ton mixer and the work of the foundation for the 800-ton mixer were so co-ordinated that, when the 800-ton shell was ready to move, the new foundation was ready to receive it. All of this was done without any curtailment in operations. To make the problem more interesting, a premature failure in a part of the lining of the 1300-ton mixer made it necessary to operate for days without a mixer and without interfering with the construction work or with the patching of the mixer. The new mixer was dried out for 48 hr by a grid gas burner installed at the bottom, and then by the main burners. Metal was run through the mixer 344 hr after the first fuel on the unit. This long heating time was necessary to allow erection of splash shields and other auxiliaries.

A complete new shell for the 1300-ton mixer is now being asembled at the same location where the 800-ton mixer shell was assembled. The old drives have been reconditioned and will be realigned and used.

Erection of a 100-ton ladle crane in the mixer building brought the number of cranes on the mixer and No. 4 open hearth charging floor runway up to four. The new unit has expedited the transfer of hot metal between the hot metal ladles and the mixers.

To handle the additional ingots produced and the extra scrap, limestone and iron ore required, 48 ingot cars and 40 charging buggies complete with boxes have been provided.

A 100-ton twin-unit narrow-gage diesel engine has been added to handle the increased work load in the mold yard, bringing the number of engines in this section up to three. The mold yard serves both No. 2 and 4 open hearths.

Originally all sections were tied in with a public address system. This afforded communication between fixed ground stations and one-way communication to mobile units. All floor cranes, charging machines and mold yard cranes are now equipped with a two-way system between mobile units and fixed ground stations. Two-way radios are being installed on the narrow gage railroad system between the locomotives and the three base stations. When this system is completed, the yard master from his desk will control all movements of the locomotives between the ingot stripper and the mills, as well as scrap shifts between the mills and the stockyard. The stockyard will be in contact with the four engines regularly assigned to it and the mold yard with the three engines there. The biggest gain in this system will be elimination of unnecessary movements and immediate contact in the event of engine failures, wrecks, blocking by trucks and other mishaps.

An increase in the electrical transmission system was required to take care of the additional load from new equipment.

The facilities for loading scrap in No. 2 stockyard and dolomite in the dolomite house were deemed adequate.

During the changes described, a period of education was required to adjust all personnel to the change from 130 to 160-ton heats furnace by furnace. Constant vigilance was required to avoid charging 160-ton heats in the wrong furnaces or tapping the larger heats in the smaller ladles. The program is drawing to a close but the challenge still remains to determine the maximum capacity of the two shops.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## GOLDEN 50 YEARS ANNIVERSARY

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## Pittsburgh, Pa.

# SOLVENT DEGREASING—

## A Valuable Industrial Process

*. . . . solvent degreasing is a versatile process, applicable for use on metals, glass and certain plastics . . . . over-all cleaning costs can be held at attractive levels. . . .*

by
W. L. McCRACKEN
Director of Research
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Detroit, Mich.

▲ THE solvent degreasing process is not new, but the phenomenal growth and increasing popularity of this cleaning process seems to warrant a complete review at this time. The definition of solvent degreasing in its broadest aspect would probably include the use of all solvents to remove soil from industrial parts. There are many applications where solvents are used cold—either in dip tanks or hand operations—to remove soil from various types of articles. The so-called hand applications of cold solvents find wide usage in maintenance work, such as large machine tools, etc. In these applications petroleum fractions are used as well as certain chlorinated hydrocarbon fractions and in some cases, mixtures of the two. This application, however, is not the one usually thought of when the term "solvent degreasing" is heard. Solvent degreasing, sometimes referred to as "vapor phase degreasing," is a process where a boiling solvent is used efficiently and economically in well designed equipment to clean industrial parts, either continuously or by the batch method. Since both liquid and vapor are utilized to advantage in this process, a better name might be "solvent-vapor degreasing."

Before the solvent degreasing process can be explored in detail, it is necessary to understand the fundamentals involved. First, it must be understood that this process cleans work by purely physical means—chemical action plays no part in the cleaning. Soil is removed from parts by either solution or solution plus the physical force of boiling solvent or solvent spray.

The ultimate in cleaning using solvent can only be accomplished by treating the part with a pure, clean solvent as a final rinse. Final contact with solvent containing soils cannot result in a completely clean part. Oily parts, immersed in a bucket or small tank filled with solvent and subsequently removed and allowed to dry, will not be clean. There will be a thin film of oil left on the parts after the solvent evaporates due to the fact that the solvent in the container became contaminated with oil while the degreasing operation was in progress. Since the object of a cleaning process is to get the parts as clean as possible, this obviously is not the correct method to use. If the solvent is heated and oily parts again immersed in it, the warm solvent will also become contaminated with oil and when the parts are removed they too will be covered with a thin layer of oil similar to the parts which were removed from the cold solvent. This in itself would not be a satisfactory cleaning process. Solvent, however, placed in a container equipped with a condenser located two or three feet above the solvent level and a source of heat to boil the solvent, results in a cleaning process. The condensate from the condenser drops back into the solvent tank. An oily part allowed to hang in the vapors inside this tank becomes a condenser. As the solvent vapor condenses on the part, the liquid solubilizes the oil and the mixture drops back into the tank where the solvent is re-evaporated and the oil stays below in solution. This process of evaporation and condensation continues until the temperature of the metal being cleaned reaches the temperature of the condensing solvent vapor, at which time no more condensation occurs. If the work piece is heavy enough so that it condenses a considerable amount of solvent before it reaches the temperature of the condensing vapor, all of the solvent-soluble soil will be removed. The hot work piece may now be removed from the vapor in a dry state without carrying with it any of the solvent from which it came. This is the solvent degreasing process in its most simple form and this most simple form is the reason why it is sometimes known as the "vapor degreasing" process. The number of degreasing processes in the United States today operating on this simple vapor cycle are very few. This simple cycle is very satis-

factory for parts which contain only oil. However, most parts contain chips ,shop dirt, etc., in addition to the oil and require some additional physical force, such as spraying with clean solvent to remove the inert particles which adhere to the metal and are not solubilized by the solvent. This simple example, however, illustrates the basic principle involved in a solvent degreasing process.

The condensate from the condenser may be collected as pure, clean solvent to be used as an immersion rinse or as a spray to assure complete cleanliness of the work, and most degreasing cycles utilize this recovered condensate in one way or another.

These fundamental principles can be summarized as follows: (1) a tank containing solvent which is boiling and which is equipped with a condenser, (2) a solvent vapor phase above the boiling liquid, (3) a means of collecting and recovering the condensate, and (4) proper control to maintain a solvent vapor-air interface at the condenser level (see Figure 1).

## THE DEGREASING SOLVENT

Some of the characteristics of an ideal solvent for the solvent degreasing process are:

1. The solvent should, of course, have high solvency power for the removal of all types of oil and greases of mineral, animal or vegetable origin.
2. It should be non-flammable and non-explosive under normal operating conditions.
3. It should have a low latent heat of vaporization so that a maximum amount of solvent will condense on a given weight of metal.
4. It should have a high vapor density by comparison with air to reduce the losses of the solvent to the atmosphere during normal operations.
5. It should have low toxic effects on workmen.
6. It should be chemically stable under conditions of operation.
7. It should be non-corrosive to common metals used in construction.
8. It is desirable to have a liquid of low specific heat.
9. It should have a fairly low boiling point to permit it to be separated easily by simple distillation from the oil which it removes from the work pieces. A fairly low boiling point is also desirable from the standpoint of keeping the temperature of the work at a reasonable level for subsequent handling.
10. The solvent should be readily available at a relatively low cost.

No solvent has yet been discovered which will meet all of these ideal characteristics. There are, however, two commercially available solvents which are certainly acceptable for this operation and have found wide usage over the years. These solvents are the chlorinated hydrocarbons, trichlorethylene and perchlorethylene. Trichlorethylene is usually more acceptable for this operation than perchlorethylene, but there are certain applications where perchlorethylene has an advantage. Trichlorethylene has a much lower boiling point than perchlorethylene, thereby giving it an advantage on several counts: (1) lower steam pressure can be used, (2) the distillation process becomes more simple and (3) the work emerging from the degreaser is much cooler.

Perchlorethylene, however, may have an advantage in degreasing parts which are contaminated with certain waxes which have low solubility but melting points above the boiling point of trichlorethylene but within the limits of perchlorethylene. In these cases the waxes are actually melted and removed from the surface of the work. Since trichlorethylene is the major solvent used in the United States today in solvent degreasing operations, this discussion is confined to trichlorethylene.

## DEVELOPMENT AND GROWTH

A brief look at the growth of the solvent degreasing process in the United States reveals that it got its start around 1930. The various solvents were examined and it was decided at that time that trichlorethylene had characteristics most suitable for this type of operation. It was soon discovered that the solvent as manufactured was not stable enough to be used in a degreasing operation. The development was therefore

**Figure 1 — Schematic view of typical solvent vapor degreaser.**

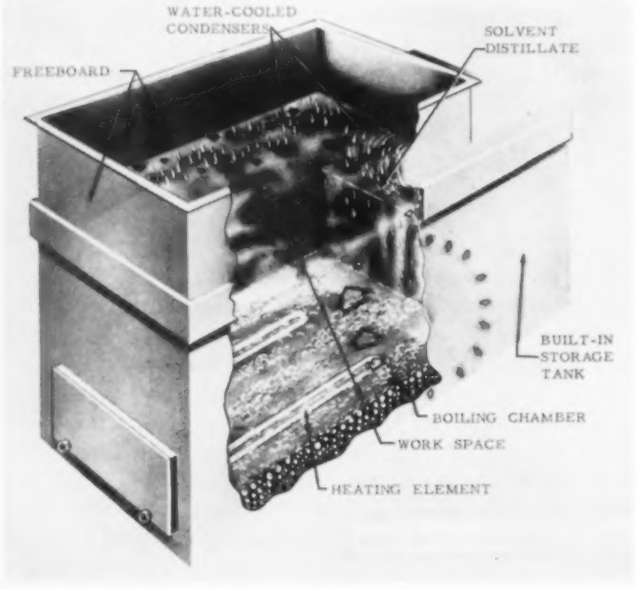
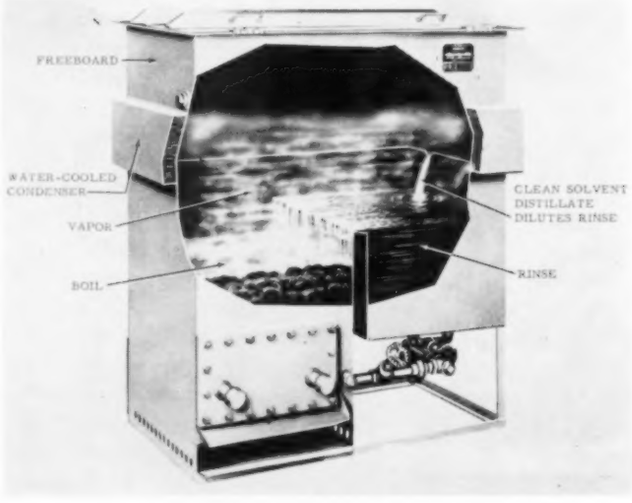



**Figure 2 — Typical two-dip, hand-operated immersion degreaser.**



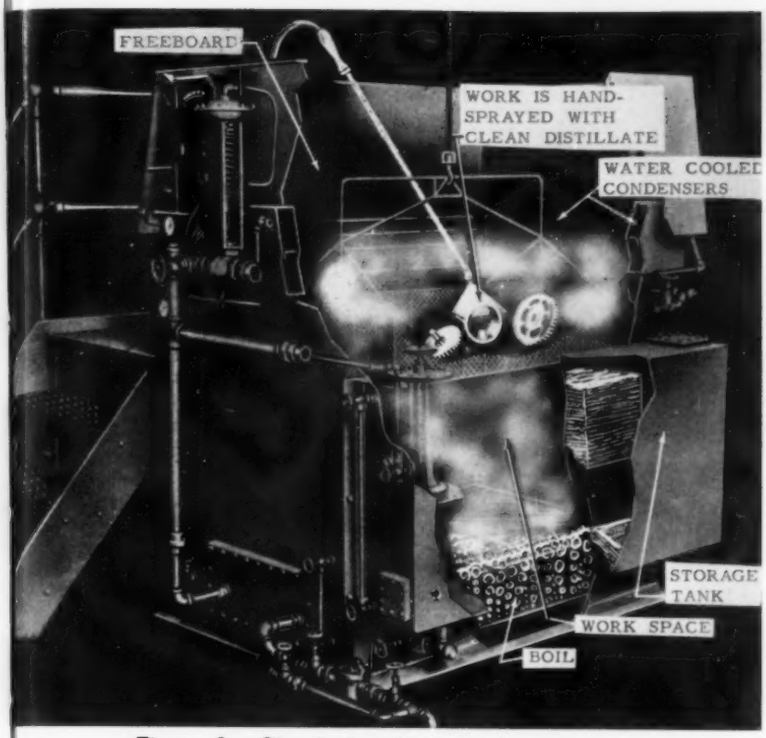



**Figure 3 — Simple hand-operated vapor-spray degreaser.**

slowed down for a short time while concentrated research on stabilization was conducted. These problems were solved satisfactorily and the process got off to a good start in the early 1930's, even though trichlorethylene was more expensive per gallon than water and detergents which were commonly used in industrial cleaning operations at that time. Once a user of this cleaning process studied his over-all costs, however, he found that solvent degreasing was economical and warranted continued use. The process had a rapid, steady growth up until World War II, at which time it received an added boost and after the war continued on a steady increase. It has been estimated that at present there are approximately 20,000 solvent degreasers operating in the United States which will consume upwards of 250 million pounds of trichlorethylene in 1956.

## SOLVENT DEGREASING CYCLES

All solvent degreasing cycles are built around the fundamentals of solvent degreasing as depicted in Figure 1. The next logical simple step to aid straight vapor degreasing is to introduce physical energy into the process by submerging the parts in boiling liquid. A degreasing machine showing this technique is depicted in Figure 2. All of the basic fundamentals shown in Figure 1 are employed. Boiling solvent is contained in one leg of a tank with a vapor layer above which condenses at the condenser level shown on the side of the tank. The condensate from the condenser is collected and run into a second leg of the tank shown in the picture as the rinse tank. This rinse solvent overflows continuously into the boil chamber, where it is re-evaporated, leaving the oil and contaminants from the cleaning and rinsing operations in the boil tank. The technique of operating requires that the work parts go through the vapor phase into the boiling solvent where they are left for a short period of time—one minute is usually sufficient. The parts are then removed from the boiling solvent, at which time the temperature of the parts is at the boiling point of trichlorethylene. The parts are then immersed briefly in the clean solvent in the rinse tank for two purposes: first, to decrease the oil contamination on the parts coming from the boil chamber, and secondly, to cool the parts so that, as they are moved to the vapor phase, pure condensate will form on the parts and give them a final rinse. During the vapor rinse portion of the cycle the temperature of the parts is brought back to the temperature of the vapor and the parts can be removed through the vapor-air interface in a dry state without removing trichlorethylene from the machine. This simple modification of the basic machine is a very important cleaning cycle in industrial applications.

Another simple way to aid straight vapor degreasing is to spray the parts with clean solvent. A simple hand-operated degreaser of this type is shown in Figure 3. Again, all of the fundamentals of Figure 1 are present. There is a tank with boiling solvent in the bottom and a vapor space between the boiling solvent and the condenser. The condenser condenses the solvent vapors and the clean solvent is collected in the spray sump. The clean solvent in the spray sump is pumped through a spray lance, wherein lies the difference between this machine and that in Figure 1. The parts to be cleaned are placed in the vapor, where all soluble soils are removed. The parts are then sprayed with clean condensate, making sure to keep the parts well below the solvent vapor-air interface, at which time the insoluble matter is removed. It is very important to keep the spray well below the solvent-air interface to prevent excessive solvent losses. Spray nozzles should never be allowed to operate above this interface. This solvent is cooler than the boiling solvent; therefore, the temperature of these parts is kept below the boiling point of the solvent or temperature of the vapor layer. After the spraying operation has been completed the parts are given a final rinse by allowing them to remain in the vapor and letting condensation occur until the temperature of the parts reach the temperature of the solvent vapors. At this time the dry parts may be removed without removing solvent from the machine. Parts are now clean and dry, and ready for the next operation.

The three basic cycles described above are: (1) vapor phase, (2) immersion in boiling solvent and immersion in rinse solvent at a temperature below boiling-vapor rinse, and (3) vapor-spray-vapor.

The type of soil to be removed from the part, the size of the part, the shape of the part, the amount of hourly production involved and many other factors are taken into consideration in determining which cycle or combination of cycles will be used in any given design.

The degreasing machines so far discussed have all been hand-operated. All of these may be mechanized for continuous production lines. Figure 4 illustrates a machine of the return type equipped with a cross-rod continuous conveyor. The work going into this machine is first immersed in the boil chamber, then in the rinse chamber and finally exposed to the vapors to effect a vapor rinse, from which it emerges dry through the solvent vapor-air interface. The solvent vapors are condensed at the condenser zone, collected and run into the rinse tank, from which it overflows to the boil

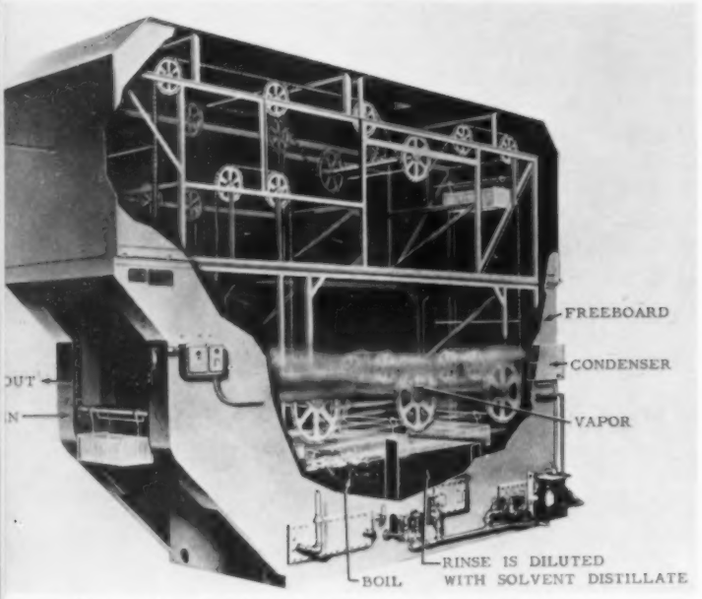



**Figure 4 — Immersion degreaser equipped with cross-rod continuous conveyor.**

**Figure 5 — Vapor-spray-vapor degreaser with straight line monorail.**

chamber. Here again all of the basic fundamentals of the simple vapor degreasing process are employed and the cycle conforms to the two-dip process shown in Figure 2, the difference being that this machine is a continuous unit. The work baskets are placed on the cross rods and removed from them at the same end of the machine.

A vapor-spray-vapor machine of the monorail type is shown in Figure 5. Work pieces are placed on the conveyor chain which carries them through the complete cycle continuously. They are first subjected to the vapor, then travel through a bank of spray headers and finally again exposed to the vapor.

Another type of degreasing machine which has gained wide popularity is the gyro design shown in Figure 6. The cycle here may be either vapor-spray-vapor or vapor-immersion-vapor. The machine can be constructed so that the work basket may dwell for a certain period of time in each phase of the cycle. After spray or immersion, the work is given a vapor rinse, where its temperature will be raised so the work will emerge in a dry condition. The reboiler or concentration chamber of these machines is separate from the immersion tank and only pure solvent condensate enters the tank where the parts are immersed. If the cycle includes sprays, the solvent which is pumped through the spray headers is solvent from the spray sump which is continuously diluted with clean condensate.

Solvent degreasing is not limited to the processing of small parts. It is used on parts varying from the size of hypodermic needles, fish hooks and even smaller to very large parts requiring degreasers that may hold as much as a tank car of trichlorethylene. The process is also used satisfactorily for cleaning strip, with a machine as illustrated in Figure 7. The top of this machine has been removed so that a portion of the interior may be seen. This is a continuous strip machine cleaning 14 strands simultaneously. This machine operates on the following cycle: (1) immersion in boiling solvent, (2) immersion in distilled rinse solvent, and (3) vapor rinse.

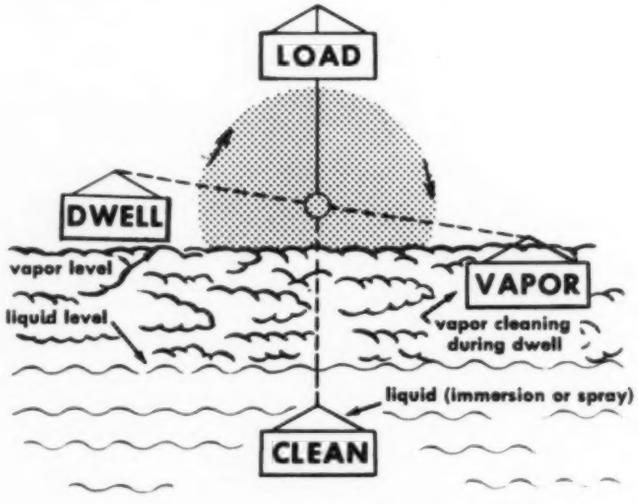
Figure 8 shows the exterior of another strip machine which is continuous in operation and processes a strip 14 in. wide. This machine operates on the cycle: (1) vapor, (2) immersion in clean solvent, and (3) vapor rinse.

The condensate from the machine flows continuously to the rinse chamber, which in turn overflows to a concentrator that furnishes the vapors for the first stage of the cleaning process as well as the condensate which flows back to the immersion chamber.

Solvent degreasing is a very flexible cleaning process, and it is easy to add other cleaning aids where and if they are needed. For example, it is very easy to augment the normal solvent degreasing process with ultrasonic cleaning equipment. Figure 9 illustrates a solvent degreasing cycle employing ultrasonic energy as a cleaning aid. In this illustration the cycle is: (1) vapor, (2) spray, (3) vapor, (4) immersion in solvent for ultrasonic cleaning, (5) spray, and (6) vapor.

This is only one of a number of different cycles which may be employed, depending upon the size and complexity of the part, the soil to be removed and the quantity of work to be cleaned. In this cycle the solvent in the ultrasonic cleaning chamber is filtered continuously to remove the particles of soil which have been

**Figure 6 — Sketch showing principle of gyro degreaser.**



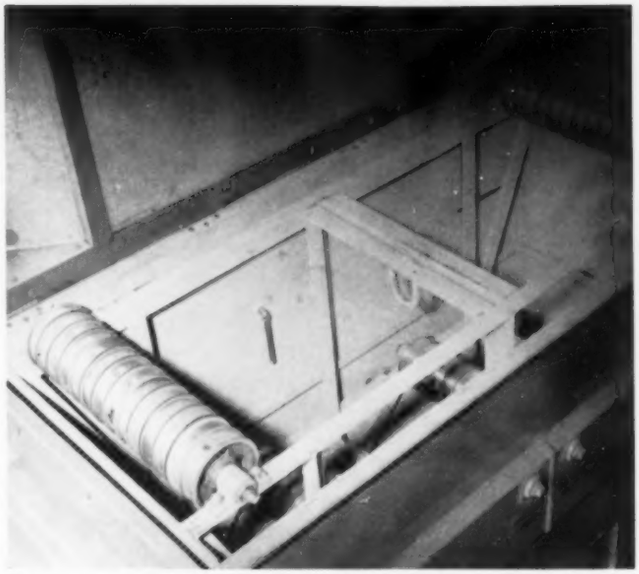


**Figure 7 — Inside view of unit designed to clean 14 strands of narrow strip.**

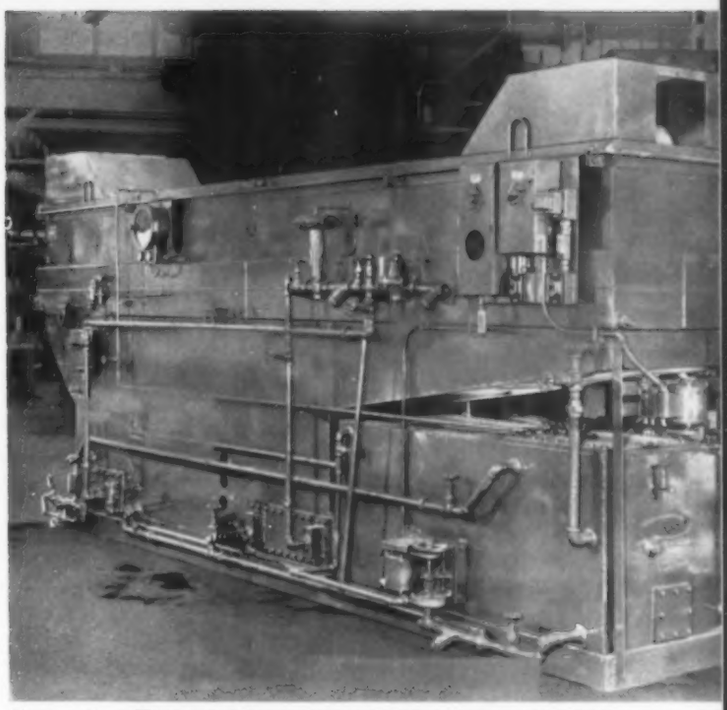


**Figure 8 — This continuous machine cleans strip 14 in. wide, using the vapor-immersion-vapor cycle.**

removed by ultrasonic energy. The parts are sprayed continuously with clean distillate as they emerge from the liquid. The use of ultrasonic energy has found widespread application in conjunction with the solvent degreasing process and seems to have unlimited possibilities in the future.

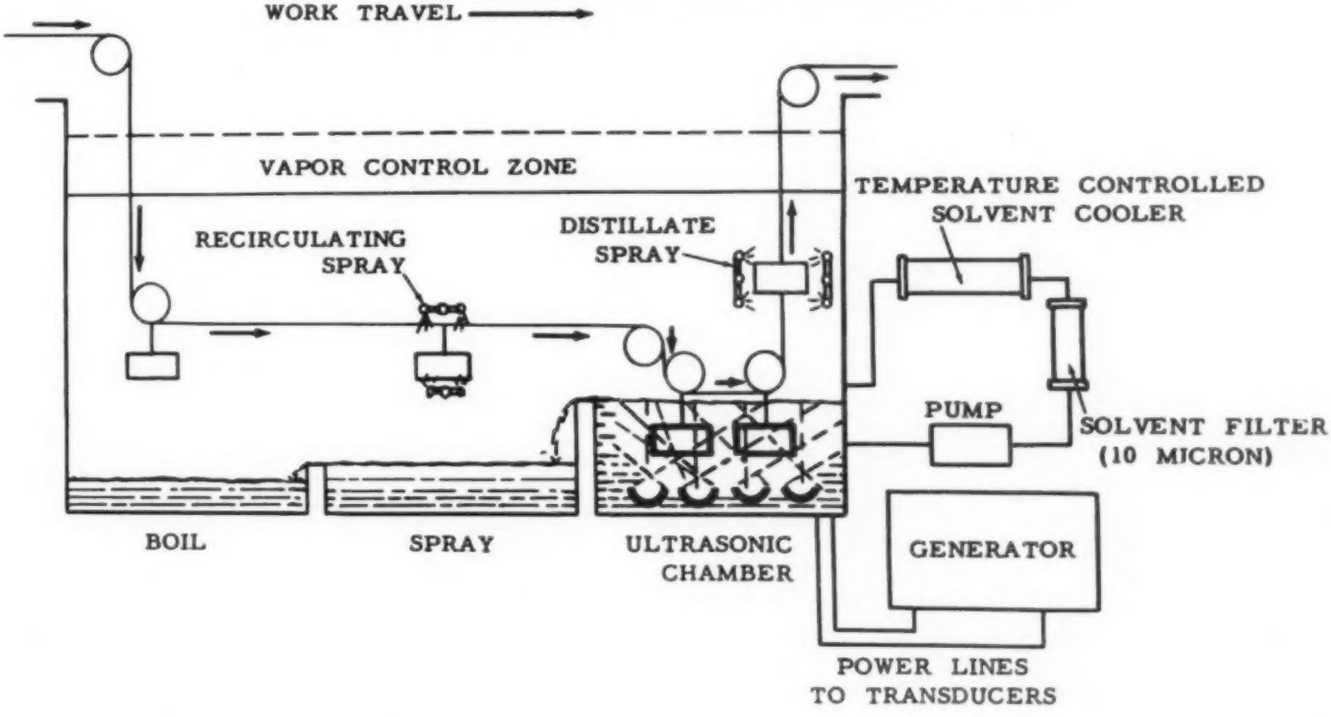
Figure 10 shows an external view of a continuous cross-rod type degreasing machine employing ultrasonic energy as a cleaning aid. The ultrasonic transducers are driven by three generators having a capacity of 2½ kw each, making a total of 7½ kw. This unit operates on a frequency of 400 kc per second.

## DESIGN CONSIDERATIONS

There are many standard designs of solvent degreasing machines which can be used for many applications. Nevertheless, the prospective user should consult a manufacturer of solvent degreasing equipment, presenting to him his specific cleaning problem, before making a purchase. It is necessary to consider the following factors in the design of equipment:

1. A study of the type of soil to be removed and a knowledge of the degree of cleanliness required for subsequent processing. This is very necessary so that the optimum cycle can be determined.
2. The shape and size of the part must be studied by

**Figure 9 — Typical vapor-spray-vapor degreaser with ultrasonic chamber.**



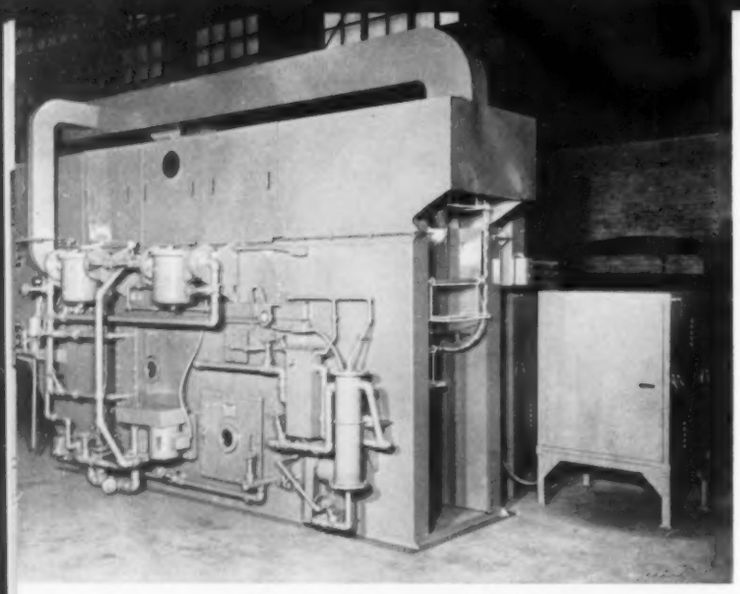


**Figure 10 — This degreasing machine, with cross-rod conveyor, uses ultrasonic energy as a cleaning aid.**

the designer. This is helpful in determining the cycle as well as the racking method to be used so that proper drainage may be accomplished.

3. The designer must know the production per hour.

4. The designer must know space limitations.

5. It is very important that the designer know the material handling methods of the plant into which the degreasing process will be integrated.

6. The designer must know in detail the available utilities, such as heat source, electrical characteristics, water, etc.

From these factors, the design engineer can lay out a unit which will assure the user a safe, economical and satisfactory cleaning process.

Trichlorethylene is a solvent which, if heated under extreme conditions, has a tendency to decompose. Designers therefore, like to see steam available as the heating source because of the ease of controlling steam pressure in the heat exchange coils. Temperatures representing 5 to 20 psi gage steam are applicable to solvent degreasing machines. Electrical and gas-fired equipment is also available and is perfectly satisfactory as long as proper controls are provided.

Various safety controls are available and advisable on solvent degreasing equipment. Some models will have certain standard control equipment but most suppliers can furnish additional controls if desired or required. The following is a list of some available controls:

1. Vapor level control.

2. Temperature control on heat transfer surfaces. This should be present on machines heated by gas or electricity.

3. Water-steam interlock, to prevent steam from being turned on unless water is running through the condenser.

4. Temperature indicators.

5. Ventilating equipment.

6. Condenser water temperature control.

Trichlorethylene as it is used in solvent degreasing equipment keeps the sidewalls free from oils. These clean side walls, if made of steel, will corrode (particularly above the condensate trough) in the presence of air and moisture. The degreasing machine is therefore always protected by covering the steel surface with galvanizing, zinc spray coat or some form of plastic lining. Nickel and stainless clad steels are often used as materials of construction for the main body of the machine. The choice of construction materials should be made by the user after consulting a qualified equipment manufacturer.

Degreasing machines should never be moved from one production line to another without first consulting the manufacturer and getting his recommendations.

## OPERATION AND MAINTENANCE

After the user has purchased a degreasing machine properly designed for the job at hand, the installation should be carefully supervised to make certain that it is installed in compliance with the manufacturer's recommendations; that cross drafts have been properly diverted; and that the machine is installed in compliance with any local rules or regulations pertaining to this type of process. Operators must be well trained in the functioning of the degreaser. The user can always get assistance from the supplier of the equipment to accomplish the preliminary program.

The operation of solvent degreasing equipment is really simple but, if the simple rules are not followed, operating costs can be higher than necessary. A few of the simple rules to follow in operating manual degreasers are:

1. Parts should be loaded in the baskets or on the hanger so that they will drain properly.

2. Work should be lowered into and raised from the machine no faster than 11 fpm.

3. When spraying solvent, keep the nozzle below the vapor line.

4. Work must remain in the vapor phase until there is no further condensation prior to removal from the machine.

These precautions are designed into mechanized machines. Hence, it is important to consult the manufacturer of the equipment before increasing the speed of a production line or changing production parts.

Regular maintenance schedules should be followed. The solvent is cleaned periodically by distillation. It may be distilled from the boil chamber or concentrator and collected in the storage tank or a still may be operated in conjunction with the degreaser, either continuously or by batch operation. Where a still is employed, the solvent is pumped from the boil chamber or concentrator to the still and the clean solvent returned to the storage tank, rinse tank or spray sump. In some cases, where companies have a large number of machines in operation, portable solvent trucks are used to transport contaminated solvent to a centralized distillation system. Clean solvent is then returned to the machine.

At definite intervals, depending upon the amount of contamination on the work being cleaned, heating coils should be removed from the machine and the boil chamber or concentrator cleaned thoroughly, removing all sediment and solids which have settled out in the bottom of the tank or adhered to the sides. Any sediment, scale or solid particles which have adhered to the heating coils should be removed so that the heating efficiency is held at a maximum. Periodic examination of the equipment should be a scheduled procedure. The opera-

or should make sure that all controls are operating properly and he should check all pumps, valve stems, cleanout doors, sight glasses, gage glasses, etc., for solvent leaks. The proper solvent level should be maintained in all chambers at all times.

### ECONOMIC CONSIDERATIONS

The operating costs of the solvent degreasing process compare very favorably and in some cases are even lower than those of competitive cleaning processes. Solvent degreasing is selected by many users in preference to other cleaning processes on the basis of its merits for a given cleaning job rather than on the basis of operating costs. For example, many production parts must be inspected several times while in process, at which time a clean, dry surface is essential. For these "in-process" cleaning applications, solvent degreasing is widely used. The process is also preferred over water type processes for applications where the surface must be kept free from water spotting, discoloring, etc. Many users select the process on the basis of savings in floor area. Operating costs will vary, depending upon the size of machine, type of machine, type of parts processed, location, method of operation and manner in which it is maintained. In general, it can be concluded that, if proper precautions are exercised in following the correct principles of operation and maintenance, overall cleaning costs can be maintained at a very attractive level.

## DISCUSSION


PRESENTED BY

**ANDREW CICHELLI**, Lubrication Engineer, Bethlehem Steel Co., Construction Engineering Dept., Bethlehem, Pa.

**W. L. McCRACKEN**, Director of Research, Detrex Corp., Detroit, Mich.

**KENNETH M. MORSE**, Chief Industrial Hygiene Engineer, United States Steel Corp., Pittsburgh, Pa.

**F. C. SCHOEN**, Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.


**Andrew Cichelli:** Are there materials that are not susceptible to this type of cleaning?

I am also interested in the lubrication of the moving parts in this equipment.

Finally, in connection with the use of ultrasonic energy as an aid to the solvent cleaning process, what considerations underlie the use of this cleaning aid? What type of process requires the assistance of ultrasonic cleaning?

**W. L. McCracken:** There are materials which cannot be cleaned in solvent degreasing equipment. There are certain plastic materials, parts coated with certain resins, certain painted parts—in other words, those materials which are soluble in or which would be attacked by trichlorethylene. For this reason there are some applications of solvents other than trichlorethylene. Methylene chloride is being used in some installations because it does not affect, for instance, a resin on a particular part. There are certain applications for freon liquids which are being used. There are one or two applications where trichlorethane is being used, even though I do not believe it is recommended for solvent vapor degreasing. I know of one or two applications where ethylene-dichloride is being used. Most of these are special applications where for one reason or another trichlorethylene is unsuitable.

The second question was about the lubrication of the machine. Naturally, lubricants should be used which are not soluble in trichlorethylene. The metallic soaps, for instance, barium or aluminum stearates, are often used. There are many lubricants on the market that are solvent insoluble. Graphite is often used in conjunction with glycerine or some other solvent insoluble material in which the graphite is dispersed.

The third question was in connection with the use of ultrasonic energy as a cleaning aid. Precision engineering demands precision cleaning, particularly in sealed units of all kinds. Lapping compound and metal particles are very difficult to remove from precision surfaces, and in many cases no other cleaning method except ultrasonic cleaning or hand wiping does a satisfactory job. Ultrasonic energy should only be employed where the conventional cleaning methods are not good enough.

**Kenneth M. Morse:** Both trichlorethylene and perchlorethylene which, by the way, are sold under a number of trade names, are both considered highly toxic solvents, having strong narcotic effects on individuals who inhale excessive quantities of their vapors. Therefore, it is most important that, in any discussion of this process, the audience should be fully informed of the potential health and safety problems, and with the various controls which can be provided for the safe application of this type of process. In 1943, I had the opportunity of studying, rather comprehensively, 108 of these machines. There are very important factors relating to the location of these machines, the speed with which they are operated and certain design and maintenance factors which determine the degree of hazard which may be experienced by the user. Furthermore, state regulatory agencies have indicated levels of air contamination above which workers should not be exposed for a continuous 40-hour work week. In the case of both of these solvents, the level established is 0.02 per cent. Therefore, I would like to hear the author's comments as to his company's recommendations concerning the size of room in which these machines should be located, location with respect to drafts, type of thermostats which should be provided for vapor control and preventing the overheating of solvent, temperature of outlet water from the condenser, and the matter of whether or not solvent degreasing machines should have exhaust hoods.

We have found, in our work, that material should not be introduced and withdrawn from the machine at a speed in excess of 20 fpm, and that the work should be allowed to drain so that "drag-out" of solvent is reduced to a minimum. Irregular shaped work may have a number of small pockets which will retain the solvent unless the work is positioned to allow adequate drainage. A hoist is probably the most effective way of maintaining proper operational speed. In regard to location, we have found that these machines should be located in a room as large as practical, with a minimum of about 15,000 cu ft in volume, with good general ventilation,

but that drafts from open windows, doors, unit heaters and ventilators should be precluded from passing over the machine. It is well to remember that such drafts will drag solvent out of the machine and increase not only the exposure of workers, but the consumption of solvent. Degreasing machines should likewise be located away from areas in which flames, furnaces or other hot operations are conducted in order to prevent the disassociation of the solvent vapor by pyrolysis and the formation of phosgene, a highly toxic gas.

In regard to machine design, it is very important that users not endeavor to alter the construction of the machine, but recognize that the machine has been developed to provide a thermal balance between the heat input and the work load. The type of chlorinated solvent for which the machine was originally designed should not be altered unless approved by the manufacturer. Where the machine is steam heated from a central steam line, each machine should be provided with a pressure relief valve set at a maximum pressure of 15 psi for trichlorethylene and 60 psi for perchlorethylene. A vapor thermostat should also be provided in the free board zone, just above the normal vapor level to shut off the heat in the event that the condenser is faulty and the vapor level rises above the condensing surface. We have found that water outlet temperature should not exceed 50 F over the inlet temperature in order to have the condenser operate properly. Local exhaust ventilation applied to degreasing machines is generally designed as $1\frac{1}{2}$ in. slots extending along the long sides of the tank through which a ventilation rate of 40–50 cfm per sq ft of tank area is maintained, with a minimum slot velocity of 500 fpm. However, it is very important to emphasize that ventilation is not a "cure-all" for poor design, poor operating practices and poor location, and that any ventilation will increase to some extent the solvent loss.

I should like to emphasize the need for thorough training of degreasing machine operators. In most instances, operators are not thoroughly trained and this is indicated by the high solvent loss, which is directly proportional to the degree of the health and safety hazard and the economics of the process. Finally, there are further health and safety problems involved in the cleaning out of degreasing machines which necessitate adequate respiratory protective devices.

We have long felt that any process which involves a potential health and safety hazard should have the hazard as fully recognized as are the operational and technical factors. Solvent degreasing is most effective and the fact that it can be done without any safety or health hazard is attested to by the many degreasing machines now in operation, but serious difficulties have occurred and they only can be prevented by fully recognizing the problems involved and taking the necessary measures to prevent their occurrence.

**W. L. McCracken:** The industrial health departments of most states recognize that trichlorethylene is toxic to a degree and have set maximum allowable concentrations in the atmosphere around the solvent degreasing equipment. Manufacturers of equipment also recognize the problem and design for maximum safety.

Size of machine, design, kind of work cleaned, and many other factors are important in considering minimum room size. Each case should be studied separately when an installation is contemplated. Strong drafts or cross drafts should be directed away from solvent degreasing equipment. Air movement, natural or artificial, should be controlled to minimize solvent loss and to maintain minimum solvent concentration in the operating area.

Any good thermostat should be adequate for controlling the vapor, outlet cooling water temperature and temperature of the heating surface. Usually the temperature of the heating surface is controlled only if the equipment is gas fired or electrically heated. A control which will throttle the heat source is adequate.

On the matter of exhaust hoods, I again do not like to generalize. In some designs they are essential, in some desirable, and in some unnecessary. Each case should be considered separately. Exhaust hoods are available and should be used when needed. Mr. Morse is absolutely correct when he says that "ventilation is not a cure-all for poor design, poor operating practices and poor location." Ventilation in addition to these may result in excessive solvent consumption.

Mr. Morse's figure of 20 fpm for introducing and withdrawing work from a machine is probably too high. Most designs are based on 11 fpm.

**F. C. Schoen:** There are several points however that I would appreciate hearing more about.

First, ventilation. As I understand it, there is a solvent loss varying from $1\frac{1}{4}$ to $1\frac{3}{4}$ gallons per ton of product cleaned, this loss being due to drag out and diffusion. Referring to a recent article in the Iron and Steel Engineer, both trichlorethylene and perchlorethylene have a maximum allowable concentration of 200 parts per million by volume in air from a health standpoint. With this in mind I would believe more stress should be given to ventilation, especially on the manual operations.

Second, fire hazard. We must appreciate that the two solvents mentioned are safe from a fire hazard standpoint. However, how safe are the vapors above the boil tank which is accumulating oils and waxes from the work pieces, some of which might easily send off vapors in the explosive range?

**W. L. McCracken:** Excess solvent should, of course, be carried away from the machine with moving air—not heavy drafts across the machine, but a gentle movement of air to carry solvent contaminated air away from the breathing zones of the operators. The design, size, location and method of operation, along with local rules and regulations, should determine what ventilation is advisable. Thousands of units are operating satisfactorily with no ventilating equipment.

As to the fire hazard, trichlorethylene and perchlorethylene are both rated non-flammable by the Underwriters' Laboratories with ratings of 3 and 1 respectively. However, if trichlorethylene vapor is mixed with oxygen at optimum concentrations and the temperature is raised to the decomposition point of the organic, using for instance a cutting or welding torch, it is possible to get a weak explosion. It is a puff and the decomposition products are carbon and acidic material, including phosgene. From the standpoint of oil contamination, there is no danger except in the case of gas-fired equipment. This equipment should be thermostatically controlled by a thermostat on the heating surface. If the temperature gets too high, the gas is automatically turned off.

By
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# AUTOMATION IN THE PRODUCTION OF RAIL JOINTS

*. . . . Inland's new rail joint line represents an application of automatic continuous production methods to a small tonnage operation . . . .*

▲ THE development of an automated line requires extensive planning and detailed study in order to devise and build a system that will function economically, consistently and accurately. The reasons for automating might be as follows:

1. Reduction in floor space. In production and final inspections alone, a single line might be amortized by reduced floor space. A small area requires much less supervision and reduced material handling.
2. Reduction in direct and indirect labor. One operator might efficiently control numerous operations, while supervision could take care of more than one line.
3. Scrap reduction and quality improvement. Good heating cycling and mechanized quenching can result in more uniform physical properties.
4. Quick-change time and good reproducibility. A well engineered line and tooling will reduce downtime and startup rejections.

## TYPES OF AUTOMATION

To the machine tool builder, practical automation means providing suitable chucking equipment, tied in with conveyors for material movement, together with interlocking operation and control.

To the conveyor people, it is providing the material at a given point, day in and out, at a prescribed rate with electronics, hydraulics, and pneumatics tied in to their almost human control.

To the writer, practical automation means automatic furnace and machine controls tied in with machine tools, conveyors, catapults, and quality control instruments.

To the reader, automation has to be a sequence of producing economically by using the best in machine tools, handling equipment, gaging, interlocking operation and control, combined to give a concept resulting in a constant flow of salable material and using a mininum amount of labor.

## EARLY STAGES OF AUTOMATION

Unfortunately, in the early stages of automation some of the dreamers suggested it must follow the line of mechanically simulated hands and electronic brains. Many novices think that this is the case today. Present day automation, however, must be simple, easily maintained and dependable.

Some of the earliest forms of automation took place in the steel industry where continuous rolling mills were developed. Heated billets or blooms are fed in and finished to various intricate sections without the aid of human hands. Numerous strands of rolls, flying shears and loopers are tied together to form a production train. Conveying rolls are often used to carry material from one operation to the other. Failure of any part in this train will idle many pieces of equipment.

In the machine tool field, automatic screw machines are good examples of early automation, where bars of metal are fed in and finished parts drop out without an operator's help. The dependability of the tooling used is responsible for the economical use of the modern multi-spindle automatics; failure of a tool or part idles the equivalent of six machines.

Automation ties machines together, so it is wise to place banks of material between them in order that the production line will not be idled because of downtime of any particular machine. Preventative maintenance is a big factor in eliminating downtime.

Those interested in the application of automation might well take a look at some of the rapid methods for replacement of major parts in high speed steel mills. Machine parts, hydraulic, pneumatic and electronic equipment must be designed so they are readily accessible for inspection and quick-change features. A designer must know how to get the most out of this equipment. He must have a knowledge of metallurgy and strength of materials, etc. He must know the latest in tool and die design and tooling applications.

Automation must, of necessity, be tailor made for

**Figure 1 — Rolled sections are placed on skids, inspected and pulled on to the roller line serving the shear.**

any specific job. It will vary from plant to plant and product to product, due to the dictates of the quality and quantity desired. The same engineering cannot be applied to a product that will be mass produced for long periods, as might be used for a product that is subject to frequent design changes and short run production.

The installation of automatic equipment will cause some problems to arise in labor relations. A reduction in lower skills will be accompanied by an increase in higher skills, requiring considerable educational work and employee upgrading. Automation will cause a dislocation of some personnel, but in the long run will not throw men out of work. Intelligent use of automation will eventually expand the use of products so that more goods for more people can be produced at lower costs. Thus instead of creating unemployment, automation results in a high standard of living for everyone.

The production and distribution of electric power is an outstanding example of the theory of automation. Flip a switch on the wall, and you will start up one of the most completely automated processes in the world. From your light switch, back through wires, meters, transformers, sub-stations, switch-gear, generators, turbines—right back to the fuel sources such as the coal pile, gas, oil, or waterhead—there are hundreds of self-supervising and self-regulating devices. This automatic process creates jobs for six-and-a-half times its own number of workers.

The automated mass production of cars, mobile equipment and household appliances are also good examples of this theory. Sure . . . the horse and carriage and their associated accessories, together with the wash tub and board, ice boxes, etc., are gone, but look at the resulting increased employment of today.

The trend of automating machine shops is comparable to that of changing hand-operated tools to power tools; hard labor is reduced and people can enjoy the better things of life.

**Figure 2 — Bars are cut to desired lengths in this 900-ton shear. A good square cut is essential.**

## AUTOMATIC JOINT BAR LINE

The floor space required by Inland's new joint bar line is 65 per cent less than the old unit occupied. This space savings was sorely needed for a new rolling mill extension. The operating force was materially reduced. A well trained electrician and mechanic must now be carried on the line full time. A decided improvement in quality control was accomplished. One turn foreman can service the line, together with our tie plate department. Setup time is materially reduced.

The training of skilled personnel posed some problems. Our maintenance men were detailed to work with the contracting engineers during the unit's construction and breaking-in period. Soon after the unit was operating they were able to make suggestions for changes in design and tooling that eliminated recurring trouble.

Our shear operator, who had a three-man crew on the old unit, now operates either manual or automatic push buttons for shear feedings, shearing and furnace charging. The automation operator operates either manual or automatic controls for heating furnace discharge, press feeding and operating, and re-heating furnace charge and discharge. He is responsible for reduction and quality of the product. During tooling changes he assists the tool setter.

In the new line, hot rolled sections of 0.40/0.50 carbon steel come in about 40-ft lengths and 15-ton bundles. These are set on skids and the bars spread out by hand. The skidman inspects and marks out bad bars or defective areas in a bar. He then pulls the bars onto the roller line where the shear feed automation clamps onto it. (Figure 1)

The shear (Figure 2) is of 900 tons capacity. It is equipped with a hold-down actuated by an air cylinder. The blades are grooved to fit the section. Clearances are governed by the section thickness; a good square cut, free from fins, is required so that the thrust from the automation catapult will work properly. Schematic drawings in Figure 3 show cropping of bar and Figure 4 shows the shearing sequence.

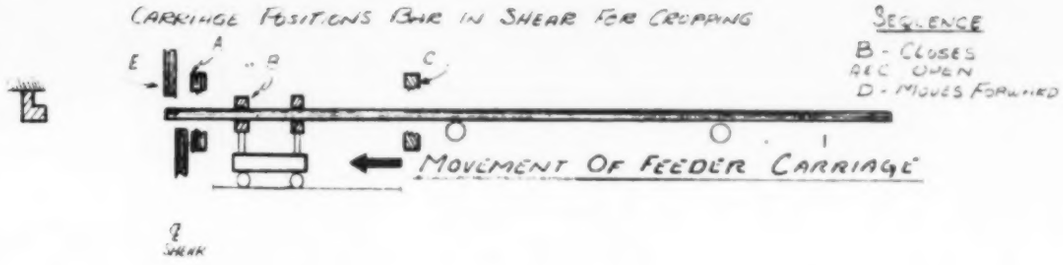



**Figure 3 — These sketches show the sequence of operations in cropping the bar.**

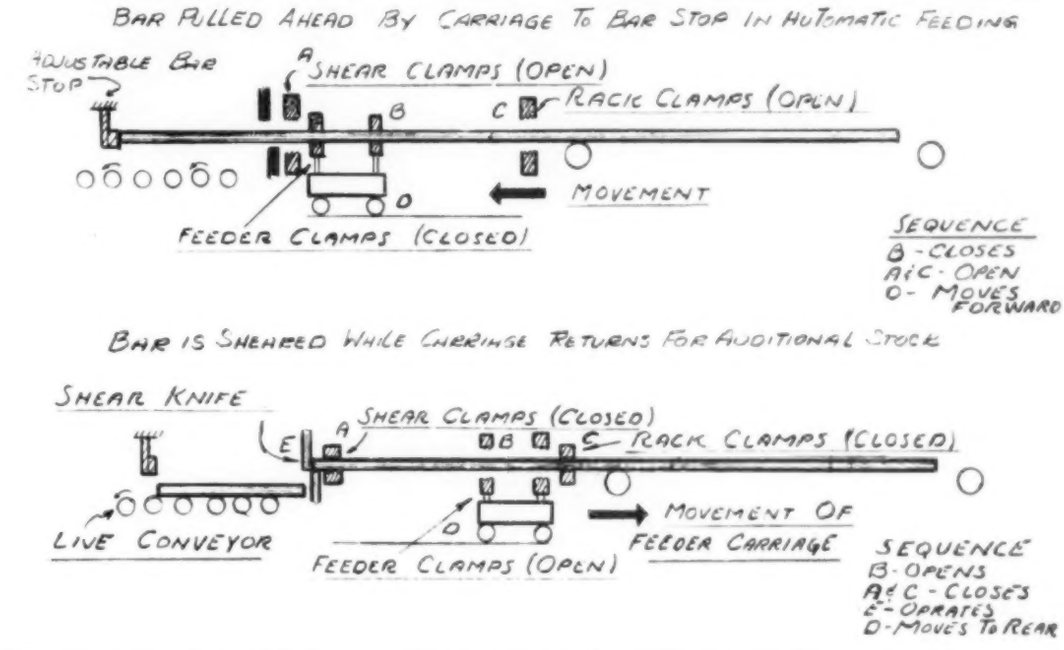



**Figure 4 — Sketches showing the automatic shearing sequence.**

From the shear, driven rolls take the sheared bars to a sweep arm which places them on two separate rows of furnace chains (Figure 5). The fingers on these chains are made of a heat-resisting alloy. They have brittle characteristics and a wreck going through the furnace can prove costly.

The furnace has hearth dimensions of 8 ft by 55 ft. Temperature and fuel-air ratio are automatically controlled. The furnace chain has a variable speed, and the temperature for fabricating is 1550 F. Schematic drawings in Figure 6 show loading of bars onto the furnace chains.

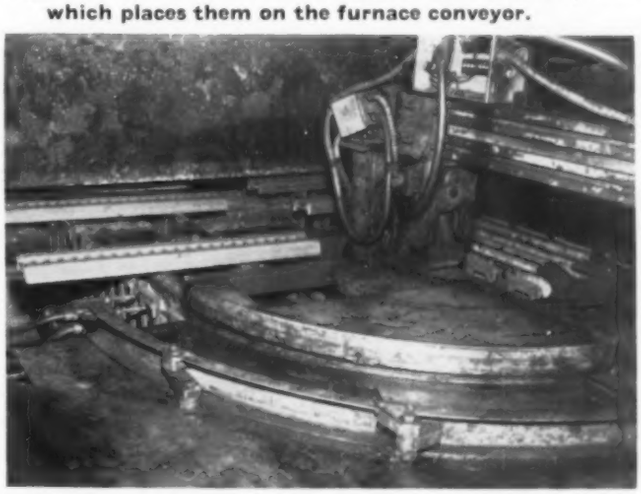
The two rows of bars coming out of the furnace are handled by a sweep arm which places them in a chute lined up with the press dies. Figure 7 shows furnace discharge.

After the sweep arm has located the bar in the chute, a catapult fires it into the press dies (Figure 8).

Three presses, each of 1150 tons capacity, are installed in a row (Figure 9). Their speed averages about eight strokes per minute, and each is synchronized with the other. After each stroke, they must come to a dead center stop.

As the bar comes into the press, it strikes a cushion cylinder which forces it back to a catapult and trips the press. The sketches in Figure 10 show sequence of operations in a press. An air-operated clamp holds the

**Figure 5 — A roller line carries sheared bars to a sweep arm which places them on the furnace conveyor.**



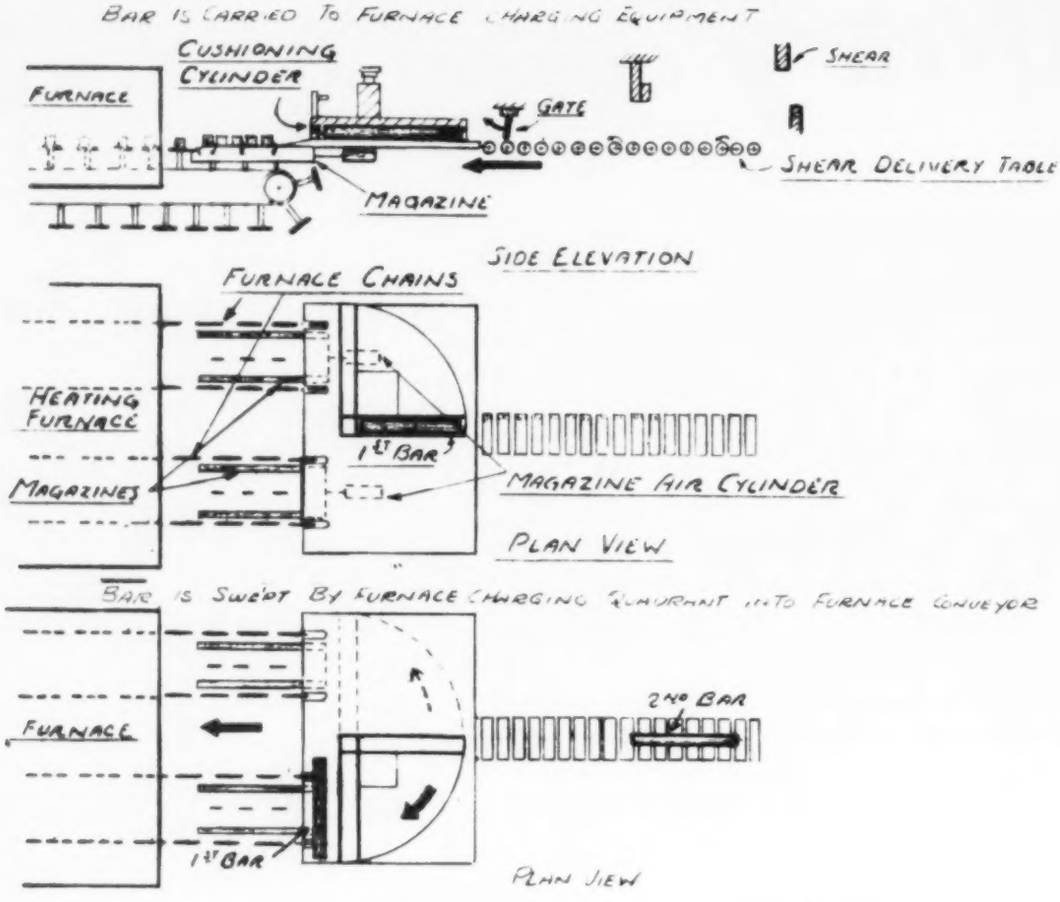



**Figure 6 — These sketches show the steps in loading bars onto the furnace conveyor.**

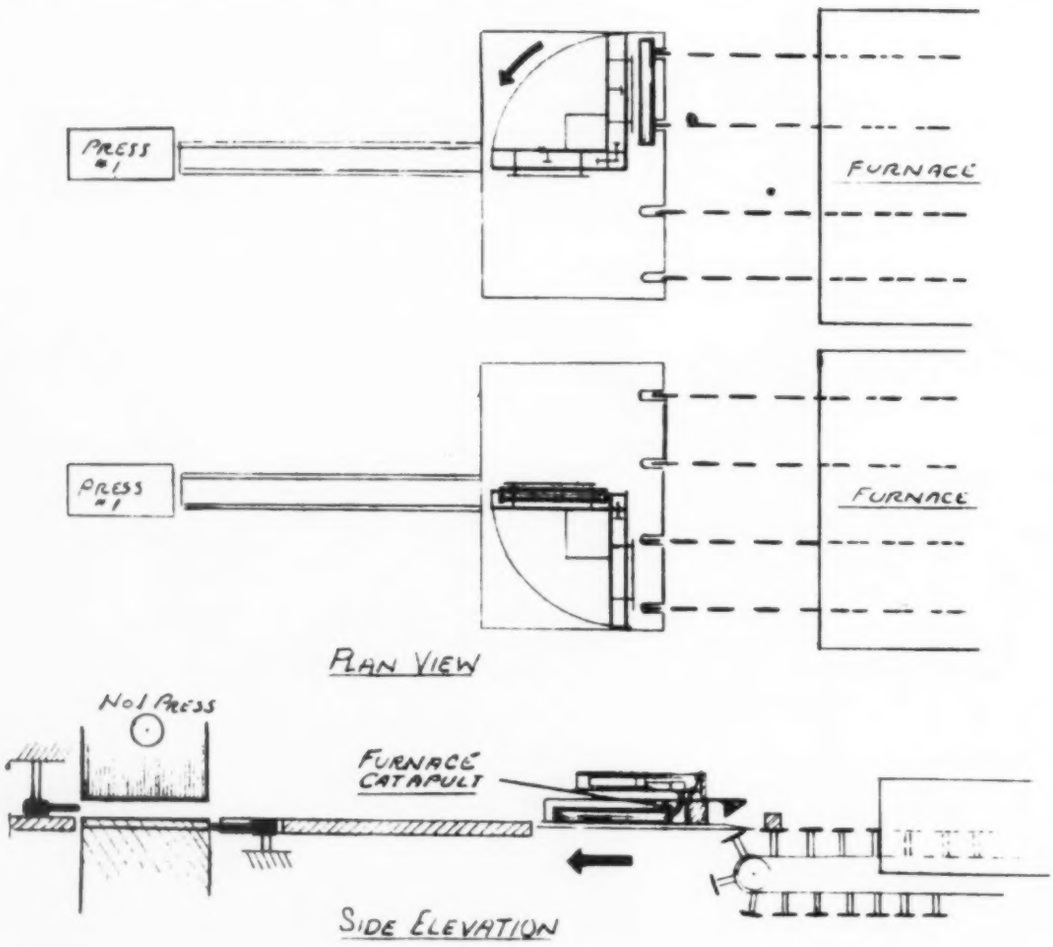



**Figure 7 — Another sweep arm moves the heated bars discharged from the furnace to a chute leading to the presses.**

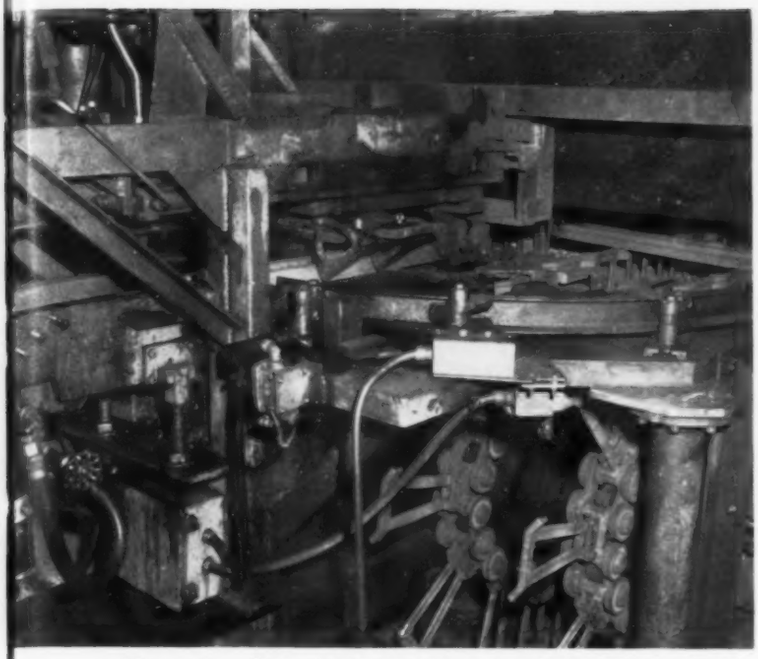


**Figure 8 — After the heated bar is located in the chute, the furnace catapult propels it to the presses.**

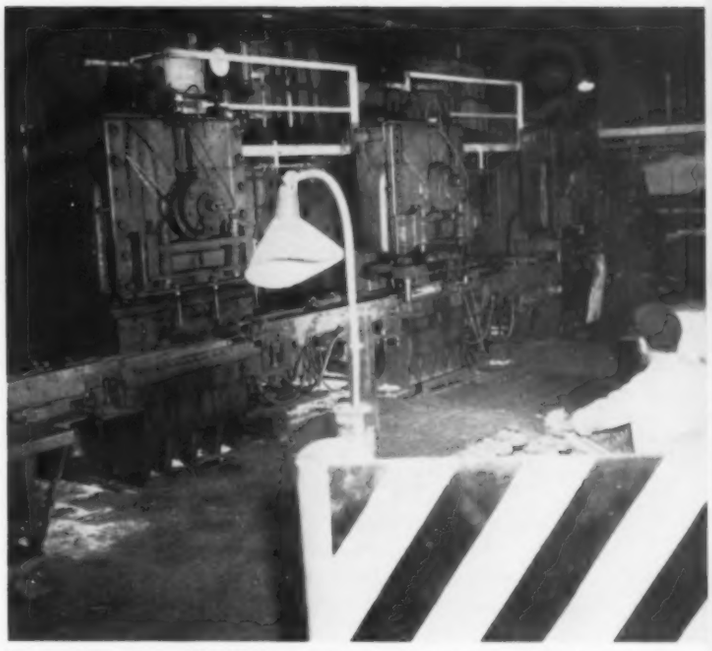


**Figure 9 — Three 1150-ton presses, synchronized with each other, operate at a speed of about eight strokes per minute.**

bar in position for punching. Punch and die clearances must be well established for each section, as any fins or bulging will cause the product to hang in the dies and the ejecting automation will not function properly.

The punches and dies are made from carefully selected hot work types of steel, and with good heat treatment, together with proper clearances, will perform for a long time.

The reheat furnace, with two rows of variable speed conveyor chains, is 8 ft by 20 ft. Temperature and atmosphere are automatically controlled. A sweep arm, located in front of the furnace, positions the bars on the chain (Figure 11). The usual heating temperature is 1550 F, and the time depends on the section being processed.

The bars discharge onto a roller conveyor which carries them to an apron plate and chute at the entry end of the 15,000-gal quench tank. A No. 5 oil is used and maintained at temperatures of 120 to 160 F. The bars are in the oil approximately 20 min.

Control testing is done with a Brinell machine. With a 100,000 psi minimum tensile strength and a 70,000-psi minimum yield strength to meet, a 220 to 269 surface Brinell range is established. The ductility requirements of 12 per cent elongation and 24 per cent reduction of area are easily met in these hardness ranges.

As the bars leave the quench tank they are dumped on a turn table which positions and delivers them to an inspection conveyor. While they are moving across the conveyor, they are inspected for surface, length, fishing dimensions, hole size, elevation, hole spacing and breakout characteristics of the punched holes.

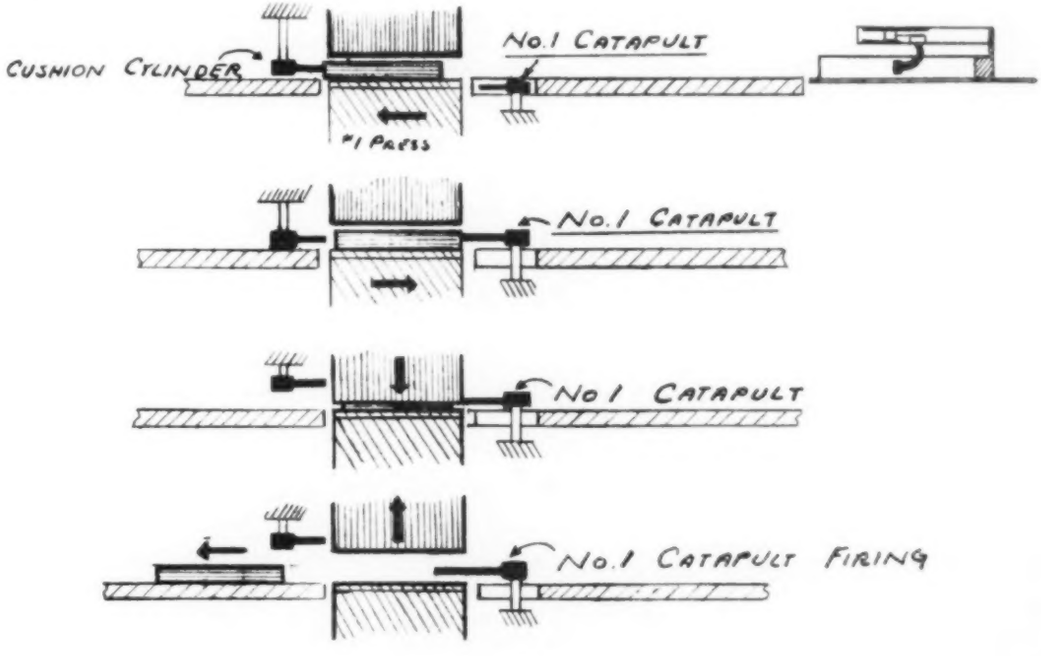



**Figure 10 — These sketches show the sequence of operations in a press.**

**Figure 11 — After being punched, bars are placed in the reheat furnace by another sweep arm. Oil quenching completes the heat treatment.**

The bars leave the inspection conveyor and are automatically piled into boxes. These boxes are then picked up by an overhead crane and dumped into gondola cars for shipment.

### SUMMARY

An automated line must be well engineered and designed. Parts must be free from stress raisers that will lead to fatigue failures. Preventative maintenance must be well planned to avoid costly downtime.

Sufficient clean compressed air must be provided for satisfactory performance of solenoids. Good heavy backing plates that will not distort must be used for oil-hydraulic connectors, so there is no chance of sticking the valve pistons.

An automated installation is economically desirable only when it continues to perform at its desired rate. Holding devices, feeding mechanism and tooling must have a high degree of predictable performance. If tool changes can be made at certain determined intervals, particularly if they can be made at the same time on all work stations in an installation, an automated setup will give excellent results.

# DISCUSSION


**PRESENTED BY**

**R. A. MILLER, Project and Control Engineer, Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.**

**C. E. CHAPMAN, Superintendent, Rail Accessories Dept., Inland Steel Co., East Chicago, Ind.**

**F. R. DAUM, Superintendent, Rolling, Finishing and Fabricating, United States Steel Corp., Edgar Thomson Works, Braddock, Pa.**


**R. A. Miller:** Mr. Chapman's paper on automation is quite timely, when the steel industry is full of expansion plans. It shows that, even with large expansion plans, they still have time to engineer relatively small jobs which handle relatively small tonnage.

I would like to ask one question. Just what is the future of automation in the steel industry as far as rail accessories are concerned. That would include rail joints, track bolts and such equipment.

**C. E. Chapman:** We are investigating production of track spikes from coiled material, using induction heating. We are now automatically loading our tie plates, using electronic weighing and recording equipment. We are investigating automation of our broaching machine, and automatic assembly of die blocks. There are opportunities for successful production and assembly automation facilities in almost every type of industrial practice.

**F. R. Daum:** Mr. Chapman mentioned the the splice bars were marked for defects prior to insertion in the shear. At that point, is the material discarded, or how is it handled?

**C. E. Chapman:** On material that is marked out, the shear automation operator will switch onto manual control, cut out defective areas and drop them into a scrap box beneath the machine.

**F. A. Daum:** There is a shear operator, then?

**C. E. Chapman:** That is right. We have only two operators; one is the operator for the shear and the other is the furnace and press operator.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# Distribution System Studies In Steel Mills

By
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*. . . . with a network analyzer, it is possible to foretell the results of changes or expansion in an existing system . . . . such studies improve the electrical engineer's understanding of his system . . . .*

▲ FUNDAMENTALLY, two considerations affect and limit the operation of electrical equipment. These are loss of effectiveness of the equipment itself and external circuit changes which demand increased performance requirements. Within the equipment, oil may carbonize and its insulation value deteriorate, insulation may age and its dielectric strength lessen, current carrying contacts may wear and erode and their performance diminish. Arc interrupting components may be reduced in effectiveness and operating mechanisms will become sluggish. Externally, the performance requirements of circuit breakers and other equipment comprising the distribution system may be affected by increased connected generation, added either by the power company or by installation in the steel mill. Short circuit capacities may increase by connection to additional tie lines, addition of large motors, the installation of synchronous condensers or large banks of capacitors, and the application of faster relaying and more severe duty cycles.

The applications of individual components of distribution systems are reasonably well standardized. Items such as transformers, circuit breakers, and motors, have standards publications prepared by NEMA, AIEE, and ASA covering rating, application and testing of these devices. However, their co-ordinated use on a complete industrial system creates problems outside the scope of these publications. Since no two mills are alike, each steel mill distribution system has its own problems which must be studied in light of conditions peculiar to that installation. These distribution problems are:

1. Short circuit conditions including interrupting and momentary requirements of circuit breakers as well as relay co-ordination.
2. Load flow problems such as line loading, voltage conditions, and reactive power distribution.
3. Stability considerations involving generators, synchronous and induction machines, and utility tie circuits.
4. Motor starting and arc furnace surges as affecting light flicker, contactor dropout, and reduced motor torques.
5. Choice of the best system grounding practice for each installation.
6. System design covering modernization and expansion programs.

## METHODS OF ATTACK

Some system problems can be readily solved. For example, the short circuit and momentary currents at any point in a radial system can be easily calculated. With the radial system of Figure 1 is shown the necessary circuit data for approximating the required interruption rating of the circuit breakers. All of this data can be obtained from the equipment nameplates except some of the reactance values, which will be available only from the manufacturer's design and test sheets.

Figure 2 shows the mva contributions of each of the sources. These are tabulated together with other circuit data in Table I. For example, the generator contributes 93.8 mva to a bus fault. The total mva for a bus fault equals the sum of the contributions of all sources and this total is 450.5 mva. This value, when corrected by the appropriate multiplying factor, is used in choosing the proper circuit breaker. For a 5-cycle air magnetic breaker, a 1.1 multiplier is used and a 500 mva breaker would be adequate for fault interrupting duty. Other factors, such as continuous and short time current ratings, must be considered in this selection. Note that the induction motor contribution was ignored above in determining the interrupting ratings, but must be included in the momentary calculations.

Steel mill distribution systems range in degree of complexity and the engineer today has a choice of the following methods of analysis: (1) arithmetical cal-

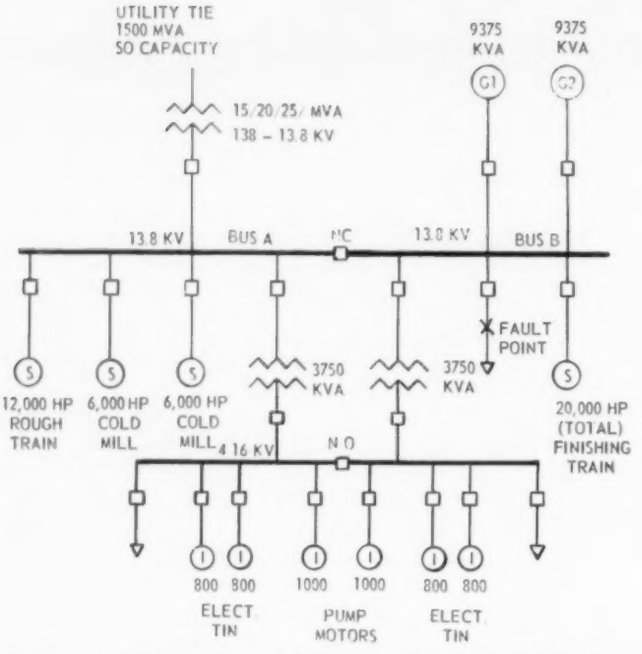
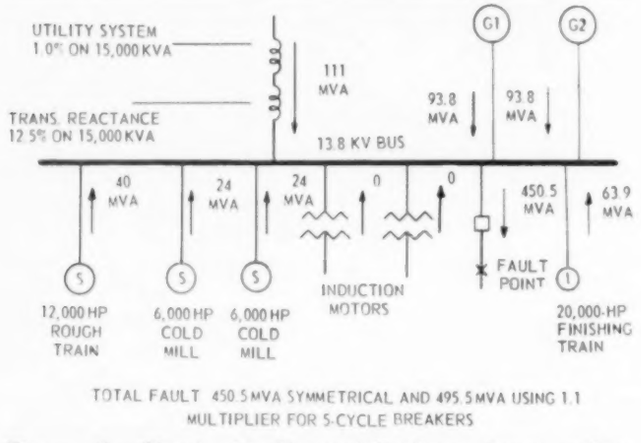



**Figure 1 — Simplicity of the typical radial distribution system facilitates system studies.**




TOTAL FAULT 450.5 MVA SYMMETRICAL AND 495.5 MVA USING 1.1 MULTIPLIER FOR 5-CYCLE BREAKERS

**Figure 2 — Short circuit contributions from various sources for near-bus fault. Total fault kva is the sum of the contributions.**

culations, (2) d-c network analyzer (3) a-c network analyzer, and (4) digital computers with or without a-c network analyzer.

*Arithmetical*—The example illustrated by Figures 1 and 2 demonstrates the arithmetical method.[1]* On a more complex system it becomes obvious that, although possible, a solution by slide rule methods is tedious and time-consuming. In the past years large utilities employed a battery of specialists wielding slide rules to obtain the information needed to properly apply circuit breakers, relays and other circuit components. The proper application of computers has taken over much of the tedious and repetitious work involved in clerical and engineering chores. A network analyzer applied to the study of distribution systems does this. It eliminates many hundreds of hours of slide rule work where properly applied.

*D-c network analyzers*—There are many d-c boards[2] existing throughout this country. As the name indicates, they are direct current boards having a number of variable resistances which can be used to represent circuit reactances. In three-phase short circuit studies, the results obtainable on the d-c boards are satisfactory. These analyzers are also useful in network simplification and other studies, are simple to use and answers can be quickly obtained. D-c analyzers cannot be used in those studies where the angle between voltage and current is significant. Thus, load studies covering voltage conditions, var-flow, transformer taps, generator loading and tie line loading are generally outside of the scope of the d-c analyzer. In addition, stability studies cannot be made on d-c boards.

*A-c network analyzers*—Because of their adaptability to complex problems a-c analyzers have been accepted as the main tool for system analysis. The possibilities inherent in their use have attracted both capital and skilled personnel to these installations. There are less than 50 of these a-c network analyzers available in the Western World. Because of the limited demand for them, only a few companies have engaged in their manufacture. The first board was made in 1929, and no more than a few per year installed since then. Many of their features are the results of suggestions by users, most of whom until recently have been utility engineers. Steel mill engineers have become interested in these tools as their plant systems and the associated problems became more complex. The authors' company is participating in the use of two a-c network analyzers, one at the Illinois Institute of Technology and the other at the University of Wisconsin, illustrated in Figure 3. On these have been solved industrial plant problems ranging from short circuit studies to transient stability investigations.

In preparing a system for representation on an analyzer, attention must be given to fitting the actual circuit characteristics to the ranges available on the board. Doing this requires a knowledge of both the system to be studied and the limitations and possibilities inherent in the equipment. The steel mill engineer, except in isolated instances, cannot be expected to be a specialist on the network analyzer. Skilled operators are available at these installations. They assign the circuits, operate the instrument desk and give other valuable assistance. The steel mill engineer, in preparation for the study, must compile the system data required for those studies which are to be conducted. This may include rotating machine loads, ratings, and impedances; transformer ratings, taps, and impedances; reactor ratings and impedances; line and load characteristics; circuit breaker ratings and speeds;

**TABLE I**

**Tabulation of Ratings, Reactances and Short Circuit Contributions of the Various Components of the System in Figure 1**

| Source | Kva | Hp | $X''_d$ per cent | $X'_d$ per cent | Mva Contribution |
|---|---|---|---|---|---|
| Gen No. 1 | 9375 | .. | 10 | .. | 93.8 |
| Gen No. 2 | 9375 | .. | 10 | .. | 93.8 |
| Utility | .. | .. | .. | .. | 111.0 |
| Roughing | .. | 12,000 | .. | 24 | 40.0 |
| Cold mill 1 | .. | 6,000 | .. | 20 | 24.0 |
| Cold mill 2 | .. | 6,000 | .. | 20 | 24.0 |
| Finishing | .. | 20,000 | .. | 25 | 63.9 |
| Induction | .. | .. | .. | .. | .. |
| Total symmetrical mva | | | | | 450.5 |

* Numbers in parentheses refer to corresponding item in bibliography at end of paper.

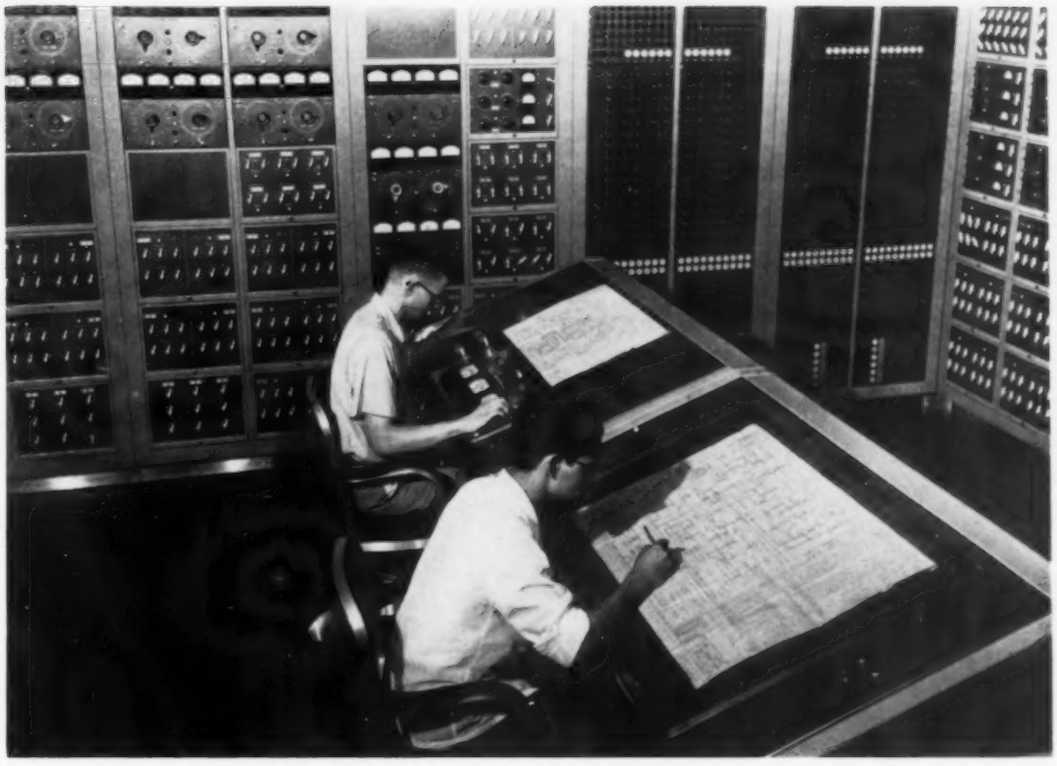


**Figure 3 — View of typical a-c network analyzer used in distribution system studies.**

and relay characteristics. The necessary data is tabulated and converted to a common base so that the proper values can be set in the network analyzer. The operator connects the individual analyzer components into a network similar to the system single-line diagram provided by the plant electrical engineer. The reading and recording of data then begins. Usually a reproducible copy of the single line is used to record the data for each system condition.

The detailed mechanics of a-c network analyzers is beyond the scope of this paper and are covered in manufacturer's instruction books. These analyzers include reactors, resistances, capacitances, auto-transformers, mutual transformers as well as generator units. These components can be combined to represent rotating machines, lines and cables, transformers and loads. It might be mentioned that the latest boards are designed in such a manner that one can set the per cent impedances and per cent susceptances (reciprocal of capacitance) directly on the calibrated dials, since base impedance and ohms impedance are the same. The operator is able to read volts, amperes, watts, vars, phase angle and vector components at any point on the system by means of a push button circuit selector arrangement at the operator's desk. Circuit identification lights at the recording desk eliminate possibilities of error in recording data.

## SHORT CIRCUIT STUDIES

Proper short circuit protection is perhaps the most critical of the plant engineer's problems. The penalties for negligence in this respect are expensive: (1) physical danger to mill personnel, (2) extended damage to equipment, and (3) prolonged unplanned shutdowns.

Short circuits of 500,000 to 1,000,000 kva and more are available on some 2400 to 13,800 volt plant busses. Faults of such magnitudes may exceed the interrupting ratings of all standard protective devices. When a fault occurs the circuit breaker or other protective device must be able to interrupt the available current. No "overloading" is tolerated in a protective device because its action is generally positive—either interruption or failure. In addition, having a circuit breaker of proper size yesterday does not mean that it is large enough today. System changes nearly always add to the fault capacities. Generation is added, tie lines strengthened, supply transformers increased in size, load growth increases motor feed-back—all of these increasing the fault duty required of the protective circuit breakers. D-c or a-c network analyzers allow a convenient means of obtaining fault duties at all system busses for any number of system conditions. If a plant generator is due for overhaul, it may mean closing tie circuits to adequately supply all busses. If a normally energized supply cable fails, perhaps a bus tie breaker must be closed to carry the load. Assume it is desired to add a new cold mill—where in the electrical system can it be most economically located? These are typical of the conditions for which data can be recorded during a board study and later thoroughly analyzed at a convenient time.

Only three-phase short circuit-studies are generally necessary in steel mills as well as other industrial plants. These faults give the largest current magnitudes, since grounding impedances practically always limit the line-to-ground fault currents to lesser values. Two values of fault current must be calculated for plant systems 2.4 kv and above:

1. The rms symmetrical value of the fault current flowing at the instant that the circuit breaker contacts part. This is termed the circuit breaker interrupting current. Under present standards an eight-cycle breaker is assumed to part breaker contacts five cycles after energization of the trip coil. Standard multiplying factors are used for the interrupting currents for faster breakers.

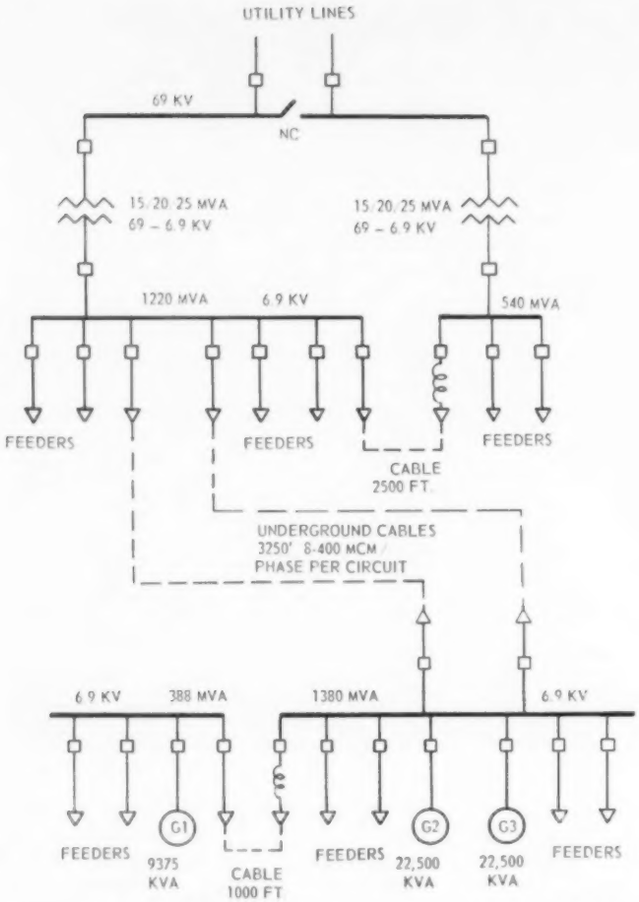



**Figure 4a — Fault capacities on various busses of 6.9-kv steel mill distribution system at time of short circuit study.**

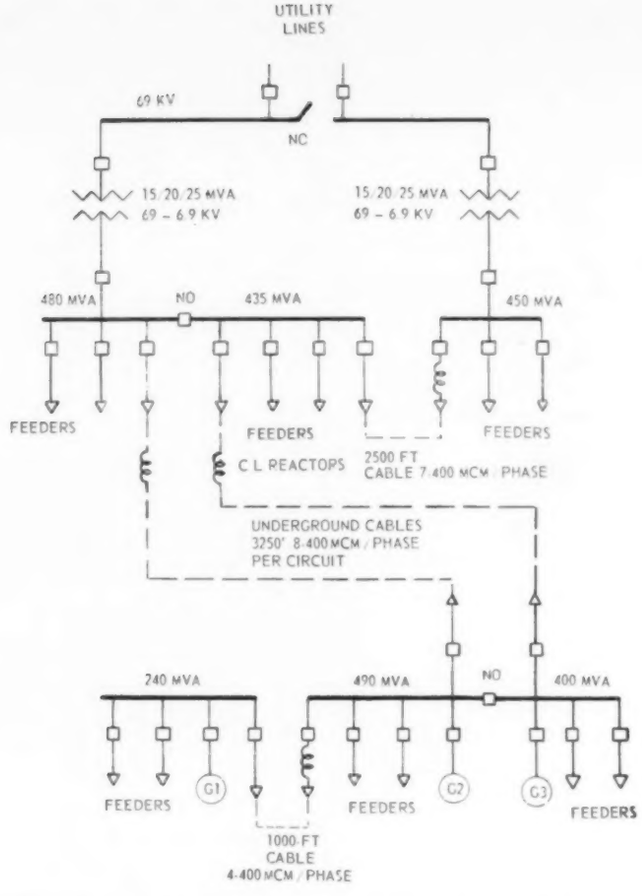



**Figure 4b — Fault capacities of the system shown in Figure 4a after changes were made as indicated by short circuit study.**

2. The rms asymmetrical value of the fault current at one-half cycle after the fault occurs. This is termed the momentary current and is the value which determines, for all equipment, the mechanical stresses resulting from the high fault currents. The symmetrical value at one-half cycle after fault is first calculated. Then a multiplying factor, usually 1.6, is applied to obtain the asymmetrical value. This momentary value is also important when considering the circuit breaker operating mechanism requirements for closing against a faulted circuit.

Since rotating machines' ability to produce fault current diminishes with passage of time after initiation of a fault, different values of reactances are used for the two calculations listed above. Recognizing the speed of modern breakers, the sub-transient reactances for synchronous generators are used in both cases. Present standardized methods for simplified calculation of fault currents have been adopted by AIEE[3] and ASA[4]. The recommended machine design reactances and multiplying factors which should be used are included. Revised methods are being seriously considered by AIEE[5].

During an analyzer short circuit study it is convenient to try various schemes to reduce fault currents as the study progresses. Some of the possibilities are: (1) splitting busses and loads, (2) opening tie circuits, (3) addition of current limiting reactors in tie, generator or feeder circuits, (4) utilizing duplex type reactors, (5) tying system busses together at a higher voltage (usually utility supply voltage) through transformers, and (6) rewinding old generators or adding new machines at higher voltages.

The primary intent in the application of fault reducing measures should be to keep fault currents down to a reasonable value and within the ratings of standard breakers. To try to match the system to the limited interrupting capabilities of old breakers can be a serious mistake, since the resulting system may not be stiff enough to maintain suitable voltage levels, especially during motor starting and other disturbances.

An example of the results from a typical steel mill short circuit analysis is illustrated in Figures 4a and 4b. Figure 4a shows fault capacities of more than 1200 mva present on both main 6.9 kv busses. The maximum interrupting capacities of the feeder circuit breakers when new were 500 mva. These breakers would certainly fail in attempting to interrupt this fault. Physical danger, equipment damage and extended outages would be the almost certain result.

Figure 4b shows the results of a short circuit study to alleviate this condition. The addition of two current-limiting reactors plus sectionalizing two busses attained the desired result. Fault capacities are reduced to less than 500 mva.

## LOAD STUDIES

Utility load studies represent the greatest work load of the usual a-c network analyzer. In large steel mill systems load studies can also be quite important. Load

studies provide data covering bus voltages and mw and mvar flow for various operating conditions. Thus they can be useful for those plants where the following types of problems are present: (1) low or high voltages at various busses, (2) problems involving ratings and range of taps on transformers, (3) critical loading on lines, cables, transformers, generators and other equipment, (4) size and location of power factor correction equipment, and (5) system changes which affect any of the above considerations.

Smaller plants having radial systems can in most cases be analyzed without the use of the a-c network analyzer. Plant load studies, with or without the a-c network analyzer, can provide benefits through improved voltages, better power factor and reduced power costs.

One characteristic of steel mill systems as compared to utility systems is that, for any voltage level, there is generally low reactance between busses. This results in a minimum of voltage problems. Between voltage levels, the reactance of step down transformers is sizable. However, if the load power factor is high, the voltage drop across the transformer is small, since the voltage is merely shifted in phase angle but not changed much in magnitude. Long overhead and cable circuits can add appreciable impedance, especially if they are a mile or so in length. A well designed steel mill distribution system avoids transferring large blocks of power long distances except at the higher voltages, thus minimizing this voltage drop problem.

## STABILITY STUDIES

In steel plants as in most other industries, system stability problems have been given limited study. The term stability is used here to describe the degree of irregularity in power supply to plant load occasioned by a disturbance such as a fault. One simple example is a fault at point "X" in Figure 5a which is cleared by transformer differential relays tripping circuit breakers A and B. During that period when the fault is on, the plant generators will speed up and tend to swing ahead of the utility system. If the fault persists long enough, the two sources will swing apart causing a partial or complete shutdown. Figure 5B illustrates a condition in which the two groups of plant generators may lose synchronism with each other. In this case a fault at "X" will tend to pull the two generating busses apart especially if the fault is cleared slowly and if most of the plant load is located at one or the other bus. Large synchronous motors can take the place of one of the sources and go out of step in a similar manner. Figure 5c illustrates this possibility. Here again a fault at point "X" will tend to pull the synchronous motors out of step. The relaying and circuit breaker speeds are decisive. Generally, when a synchronous motor falls out of step, its protective equipment removes it from the line. Thus the major consequence is usually loss of the synchronous motor load itself as the remainder of the system will probably ride through the disturbance.

In all of these examples the system voltage profile in the face of a bus short circuit is important. Some steel mills lose the entire load upon the occurrence of a bus fault. The reasons for this are twofold:

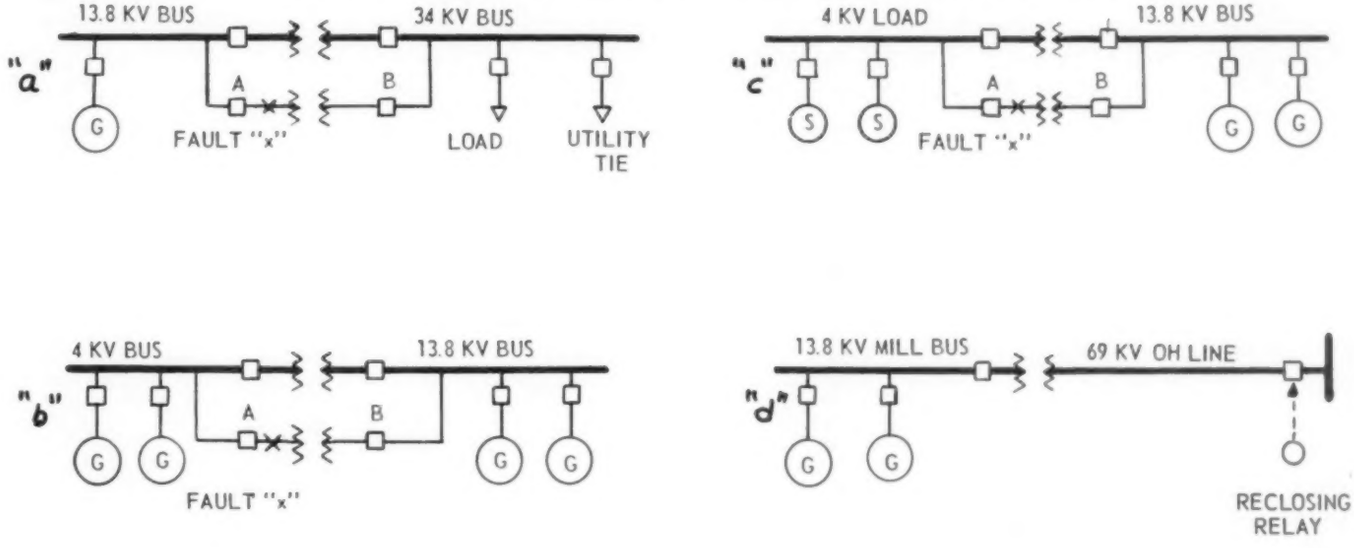
1. All busses are operated with tie circuits always closed. With concentrated heavy loads, these tie circuits have little impedance and, consequently, a fault on one bus practically amounts to a fault on all busses.

2. Old slow speed oil breakers, pampered by slow relay settings, do not clear the faults fast enough.

As a consequence of these conditions the bus voltage drops, motors all decelerate and the supply sources are not able to pull everything back up to normal when the fault is finally cleared. Induction as well as synchronous motors are adversely affected in this manner and thorough stability studies[6] are sometimes conducted for critical processes. For the condition of prolonged low voltages at distribution busses, motor stability can be improved by installing motors with higher torque characteristics and contactor drop-out can be eliminated by introduction of time delay in the drop-out time or lower contactor drop-out voltages.

A common stability problem found in utility systems is not generally present in steel plants. That is where

**Figure 5 — Examples of stability problems encountered in steel mill applications. (a, upper left) stability between mill generator and utility tie circuit; (b, lower left) stability between two groups of mill generators; (c, upper right) synchronous motors can pull out of step; and (d, lower right) reclosing relays on utility high voltage breaker.**



overhead lines tie various machines together and reclosing relays are used to restore the circuits after temporary faults. Reclosing relays are sometimes used on utility supply lines to steel mills as shown in Figure 5d. However, since the plant load remains connected, the plant generators are more likely to slow down than speed up. The problem then becomes one of load shedding rather than stability, particularly if the plant load is much greater than the capacity of the plant generation.

Whenever important stability problems similar to those described are recognized, they can be solved on the a-c network analyzer. It is desirable to make several runs with varying system conditions and clearing speeds if unstable conditions are approached. Typical solutions to an unstable system by distribution system changes may be: (1) adding a tie circuit, (2) using faster relay settings, (3) installing modern 3- and 5-cycle breakers, and (4) reconnection of feeder circuits to different busses.

## MOTOR STARTING PROBLEMS

Full voltage starting of large synchronous or squirrel cage induction motors usually creates the greatest voltage disturbance of all normal electrical functions in a steel mill. While practically all newer motors are designed so that they can successfully withstand the rigors of full voltage starting, the adverse effects on the power distribution system must be reckoned with. The most important considerations are:

1. Initial minimum voltage dip resulting within the first several cycles after energization. This minimum voltage determines whether other contactors supplied from same bus or nearby points will drop out. It sometimes creates light flicker problems and in some cases may cause synchronous motors to pull out of step and induction motors to stall.

2. Restored voltage, or that voltage resulting after automatic regulating devices have acted. For cases where mill generators are equipped with modern regulators, the voltage will increase sharply after reaching the minimum point, due to increased generator field excitation. The magnitude of the restored voltage at the motor will determine if the motor can develop enough starting torque for the application and continue to develop more torque than the load demands throughout the accelerating period. At the end of the accelerating period, synchronous motors must have sufficient torque to pull into step. Low restored voltages at busses can damage local contactors by reducing contact pressure and in some cases burn out operating coils.

For starting larger motors the alternatives are accepting the increased installed costs of reduced voltage starting equipment as against tolerating the system disturbances outlined. A survey must be made to determine which of the foregoing hazards are likely to occur. Then a study of minimum and restored voltages must be made for the various conditions under which the motor will be started. This type of study can usually be limited to the portion of the distribution system supplying the motor to be started. This simplification allows one to estimate the resulting voltages to within a few per cent, which in most cases is satisfactory. However, some systems are closely knit, so that all busses are affected appreciably. If the equipment which is vulnerable to voltage drop is not adjacent to the motor being started, the whole system is involved. A network analyzer study is then indicated. More detailed system performance as well as alternate system operating conditions can be investigated. Load considerations such as the beneficial effects of synchronous motors can be included since this work is not usually too involved. These motor starting studies can conveniently be carried out during the final day of short circuit study.

Table II shows the resultant bus and motor voltages which occur upon the starting of a 2000-hp motor for six system conditions. The single line diagram for this is shown in Figure 6. The voltages were estimated through the use of curves and slide rule calculations.

In the system of Figure 7, the effect of full voltage starting of an 8000-hp synchronous motor on bus no. 3 is under consideration. The results of this motor starting study are tabulated in Table III for eight different system conditions. The study included the beneficial effects of a 10,000-hp cold mill synchronous motor running unloaded on the same bus. Because of the tie circuits this latter problem was better adopted to the network analyzer and an opportunity was available for its use in making the study.

## SYSTEM GROUNDING

System grounding in steel mill distribution systems involves many considerations. Existing equipment, method of operation, nature of load, sources of power, availability of equipment neutrals, type of feeder lines, lengths of cables, presence of surge capacitors and experience of operating and maintenance personnel all have a direct effect in the grounding picture. Yet

**TABLE II**

**Estimated Values of Minimum and Accelerating Voltages and Motor Starting Torques for Circuit Conditions Specified in Figure 6 When Starting 2000-hp Synchronous Motor**

| System condition | Circuit | | | | Minimum voltage | | Accelerating voltage | | Starting torque at motor |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | At bus | At motor | At bus | At motor | |
| I | x | - | - | - | 68 | 63.5 | 88 | 82.5 | 67.5 |
| II | x | - | - | x | 70 | 64.5 | 75 | 69.5 | 48.0 |
| III | x | x | - | - | 81.5 | 75.5 | 100 | 93 | 86.5 |
| IV | x | x | - | x | 83 | 77 | 100 | 93 | 86.5 |
| V | x | - | x | x | 92 | 86 | 98 | 92 | 84.5 |
| VI | - | - | x | x | 89 | 83 | 89 | 83 | 69.0 |

Note: All values are in per cent of normal voltages.
x denotes breaker is in closed position.
A, B, C and D refer to specific breakers in Figure 6.

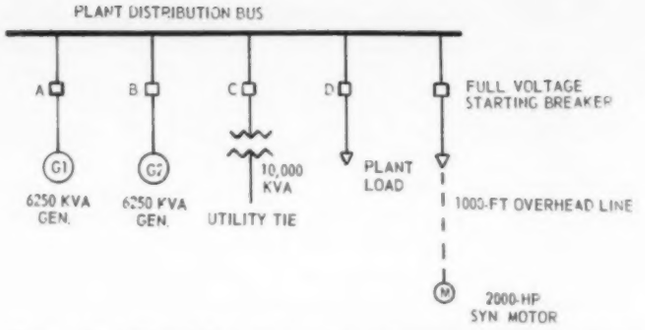



**Figure 6 — Simplified system for estimating effect of full voltage starting of 2000-hp synchronous motor. Six system conditions and results are tabulated in Table II.**

the choice of an adequate if not the best grounding scheme for any particular installation is not complex. The reason for this is that, for practically all systems, each voltage level can be studied without regard to the other voltages within the plant. The only requirement to fulfill the above statement is that there be at least one delta winding in the two winding transformers between these voltages. Ground disturbances existing at one voltage cannot be transferred through the transformers to the other systems. In those mills where radially fed transformers supply loads through radial feeders, each transformer secondary system can be treated as a separate problem even though several may be at the same voltage level. The nature of the load may indicate different schemes of grounding for system segments at the same voltage level. It can be seen that the a-c network analyzer is not particularly useful in the consideration of steel mill grounding problems.

Many systems are operated successfully without intentional connection to ground. Past experience has shown that some of these systems have excessive insulation failures due to transient overvoltages. When low resistance grounding has been applied to alleviate those problems, it has usually been successful.

The details of the various grounding schemes commonly used in industrial plants including steel mills are readily available.[7] At the high distribution voltages (usually 34.5, 69, and 138 kv), lightning arrestors, transformer insulation and utility relaying requirements are the predominant factors. Solidly grounded systems at these voltages are common.

In the medium distribution voltages, 2.4 to 13.8 kv, concern centers around obtaining enough current for ground relaying but not enough to cause expensive

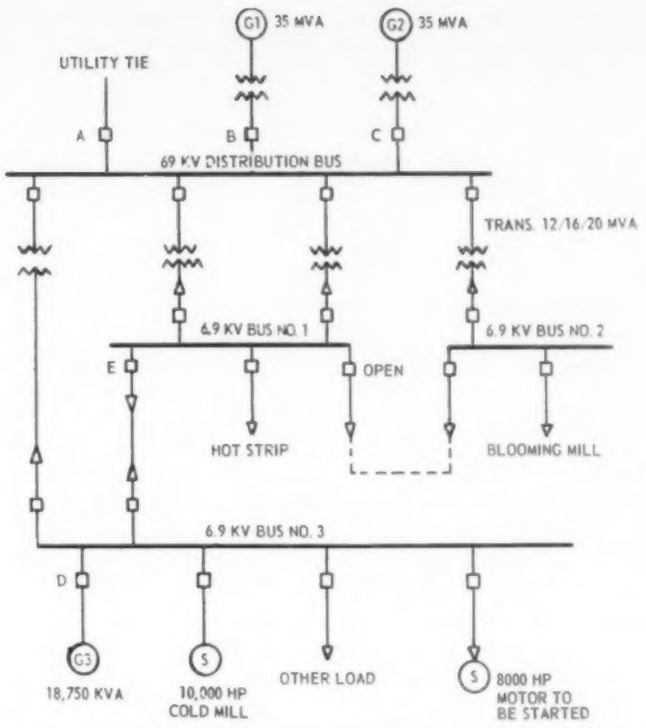



**Figure 7 — Typical distribution system posing problem of starting 8000-hp motor on No. 3 bus. Bus voltages are tabulated in Table III.**

damage such as burned iron laminations in motors or transformers. In the case of resistance grounding the $I^2R$ loss in the resistor is kept low enough to prevent damage to a plant generator when the sudden ground fault resistive load is applied. Probably most commonly used is a grounding resistor suitable for limiting the maximum L-G fault current to a value between 1.0 to 1.5 times the rating of the current transformer in the largest feeder but not less than 5 per cent of the three-phase current. It is generally sufficient to use the following approximation:

$$R = \frac{V_{L\text{-}N}}{I_{L\text{-}G}}$$

where R is resistor ohms, $V_{L\text{-}N}$ is the line-to-neutral voltage, and $I_{L\text{-}G}$ is the maximum line-to-ground fault current arbitrarily selected in the manner previously stated.

If a plant generator is used to carry base load this resistor can generally be located in its neutral. If the supply transformer secondary is wye-connected, that

**TABLE III**

**Per cent of Normal Bus Voltages Resulting from Full Voltage Starting of 8000-Hp Motor on Typical System of Figure 7**

| System condition | Circuit | | | | | 6.9-kv bus No. 1 | | 6.9-kv bus No. 2 | | 6.9-kv bus No. 3 | | 6.9-kv bus | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | R | D | R | D | R | D | R | D |
| 1 | x | x | - | x | - | 98.8 | 98.8 | 98.0 | 98.0 | 89.0 | 87.0 | 98.7 | 99.0 |
| 2 | - | x | - | x | - | 94.0 | 93.0 | 93.6 | 92.5 | 87.0 | 84.2 | 94.1 | 93.0 |
| 3 | - | x | x | - | - | 93.3 | 91.5 | 93.0 | 91.0 | 78.5 | 72.0 | 93.4 | 91.5 |
| 4 | - | x | x | - | x | 87.6 | 85.0 | 91.5 | 89.9 | 86.5 | 83.6 | 92.0 | 90.1 |
| 5 | - | x | - | - | x | 84.4 | 80.7 | 87.8 | 85.0 | 83.2 | 79.1 | 88.4 | 85.5 |
| 6 | x | x | - | - | x | 92.9 | 91.6 | 97.2 | 96.8 | 91.6 | 90.0 | 98.0 | 97.4 |
| 7 | x | - | - | x | x | 94.0 | 93.2 | 97.0 | 97.0 | 93.2 | 93.2 | 97.8 | 97.4 |
| 8 | x | - | - | x | - | 98.7 | 98.4 | 98.2 | 98.0 | 89.2 | 87.1 | 99.0 | 98.7 |

x denotes circuit breaker is in closed position.
A, B, C, D and E refer to specific breakers in diagram of Figure 7.
R and D refer to "running" or "down" condition of 10,000-hp synchronous motor of 6.9-kv bus No. 3.

neutral point can be used. An alternate grounding point is desirable for those periods when the grounded generator of transformer is out of service. In some installations it may be more desirable to use two simultaneous grounding points to eliminate the necessity of switching grounding devices. Where the ground fault currents are limited as suggested in the preceding paragraph, there is not much danger from circulating currents through the grounding devices. Where no neutral point is available, it is common practice to install a zigzag grounding transformer and connect the resistor to its neutral.

Reactance grounding is inferior to resistance grounding in most steel mill systems. Extremely low impedance grounding is avoided because of the high ground fault currents involved. Where plant generators are applied in generator-transformer unit connection, a standard single phase distribution transformer with resistance loading is recommended.

While every circuit outage is undesirable some loads are extremely critical in this respect. High resistance grounding schemes have been applied successfully to eliminate a circuit breaker operation upon the occurrence of a ground fault. Such schemes merely sound an alarm or give some other indication that a ground fault is present. The trouble is then located and corrected when convenient. The principle advantage of high resistance grounding over an ungrounded system is that, when properly applied, the system is relatively free of transient overvoltages which plague certain ungrounded systems. It is believed that the success of high resistance grounding schemes in the face of line-to-ground faults is in a great measure dependent upon efficient methods of locating faults and prompt action in removing them.

Low voltage (600 volts and below) grounding problems are similar to those in the medium voltage class. Usually no intentional grounding impedance is added. High resistance grounding is sometimes applied in the same manner and for the same reasons as described for medium voltage systems. Solidly grounded transformer secondaries are quite often used when the neutrals are available. Low resistance grounding is not generally applied for these reasons:

1. Circuit, ground and fault impedance in low voltage circuits are appreciable. Since low voltage switchgear does not usually include ground relays (only phase series trip devices), there may be a lack of sufficient ground fault current to trip.

2. There are few if any plant generators at these voltages. Solidly grounding of generator neutrals imposes the risk of machine winding damage on a single line to ground fault. These windings are designed for a maximum current of the three-phase fault value. Single line-to-ground fault currents are greater than three-phase fault currents in solidly grounded machines.

## MODERNIZATION AND EXPANSION STUDIES

Changing a distribution system is done to better handle present power requirements and to more readily accommodate future needs. These improvements are slanted toward one or more of the following:

1. Reduction in power costs by means of better power factor, better demand factor, improved metering arrangements and smaller firm purchased power requirements.

2. More reliable power sources and continuity of supply to loads by improved equipment giving better performance and requiring less maintenance and fewer outages. Also a more flexible system using alternate circuits, allowing isolation of defective equipment, and providing for future changes.

3. Safety to personnel and equipment through adequately rated electrical equipment, in good condition and arranged so that a simple, logical and direct scheme of operation insures promptness in action with a minimum of human error.

4. Less maintenance in both labor costs and repair parts. This allows power distribution engineers to concentrate their time on forthcoming distribution re-

**Figure 8 — Alternate scheme for system study covering future expansion of system shown in Figure 4a.**

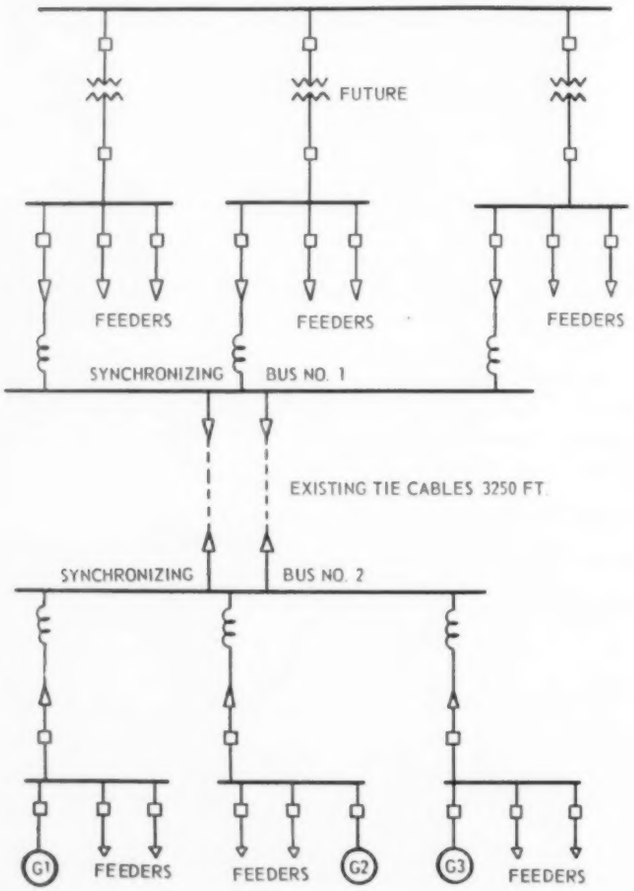
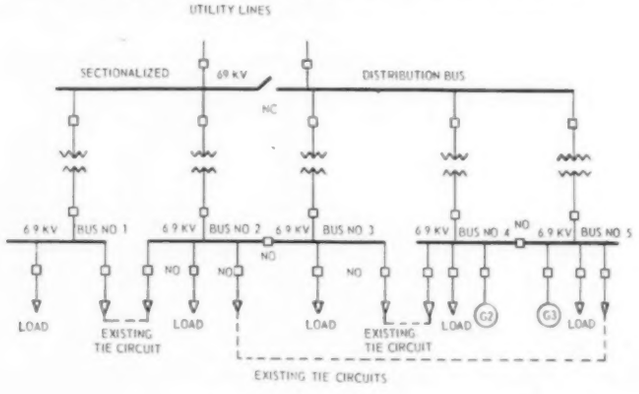



**Figure 9 — Another alternate scheme for system study covering expansion of system shown in Figure 4a.**



quirements without being burdened with excessive breakdowns or maintenance problems which should be a matter of routine.

All of the previously listed studies—stability, short circuit, load flow, motor starting, etc.—can be considered a part of any modernization and expansion study. Yet the first and major basic problem to be solved is one of primary circuitry. This practically always amounts to a higher in-plant primary distribution voltage which may be an increase from 2.3 kv to 13.8 kv for the smallest installations to perhaps a change from 34 kv to 138 kv or even 230 kv in the largest plants.

In planning a distribution voltage change it must be recognized that certain fixed characteristics exist in each plant. Thus an economic analysis will limit practical solutions to a maximum of two or three schemes. The network analyzer can be of valuable assistance in the final choice of the distribution system. Each distribution system under consideration is in turn applied to the network analyzer. A study of short circuit kva available at the various system locations will often give sufficient information for comparative purposes. This will check existing circuit breaker sizes, indicate current limiting reactor requirements, give an indication of possible problems in the starting of certain large motors and can be of some assistance in estimating stability problems. Momentary as well as interrupting requirements can be checked. Various operating conditions with certain tie lines open or closed or with new ties added are covered. Future loads as well as varying power supply conditions are included.

One distinct benefit resulting from an analyzer comparison of two possible distribution schemes is that it gives the electrical engineer an intimate "feel" of his system. This is of course a basic strong point of an analog type device and its effect of improving the steel mill electrical engineer's understanding of his system can be immediately recognized.

One possible expansion scheme for the system of Figure 4a is that shown by Figure 8. This utilizes a synchronizing tie bus at each end of the mill with existing cables connecting the two busses together. Reactors are necessary in each of six circuits. One serious disadvantage of this scheme is that a fault in any of the tie cables could shut down most of the plant load.

The same system can be expanded to that shown by Figure 9. The existing tie cables can be kept open at one end ready for use in emergencies. Yet, during normal operation, a tie cable fault merely affects the one bus from which it is kept energized. This essentially radial arrangement is adaptable to step-by-step expansion without increasing the fault interrupting requirements of the 6.9 kv breakers.

After the most promising schemes have been proved workable, economic studies[8] as well as equipment and installation cost tabulations are often necessary to obtain budget approval of the project.

## SUMMARY

Series or perplexing circuit or operational problems are common in steel plants. Solutions to these problems are often obtainable only through a co-ordinated system study. It is not necessary to install the new generator, the transformer or the tie line and then investigate what effect the new equipment has had on the system. These and any combination of equipment installations can be prestudied with an analyzer in a matter of a few hours. Planning groups of several steel companies, fully aware of this, are now making periodic studies of their systems.[9] The experiences of these engineers point the way to increased system studies in steel plants of all sizes.

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7. "Grounding of Industrial Power Systems," AIEE, Publication 953, Oct., 1956.
8. "Economic Studies Applied to Industrial Power Systems," by H. B. Backenstoss, AIEE Transactions, Vol. 75, 1956, Part II, pp 61–70.
9. "Network Calculator and its Use in the Steel Plant," by S. Ein, 1950 Proceedings AISE, pp 143–149.

# DISCUSSION

**PRESENTED BY**

**H. E. LOKAY, Distribution Engineer, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.**

**HOWARD N. COX, Application Engineer, Apparatus Sales Div., General Electric Co., Los Angeles, Calif.**

**M. J. BEAUDOIN, Assistant Superintendent, Electrical Maintenance Dept., Kaiser Steel Corp., Fontana, Calif.**

**D. DALASTA, General Engineer, Switchgear Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis.**

**FRANK NOLAN, Application Engineer, Switchgear Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis.**

**H. E. Lokay:** As an aid to the industrial plant engineer the d-c network analyzer has been used for many years, but it has only been in recent years that the a-c network analyzer is being recognized as an important tool for industrial plant engineers as well as for power company engineers. With the continuous expansion in steel production facilities, the a-c network analyzer will soon become a "must" for all major distribution system planning.

Of the distribution problems discussed in the paper, the most important today is the last one discussed—system design for modernization and expansion programs. It stands as the most important because it includes all of the other five problems the authors discussed, plus the requirement of an economic step-by-step procedure toward reaching the ultimate design. In fact, each step of the procedure requires studying each problem.

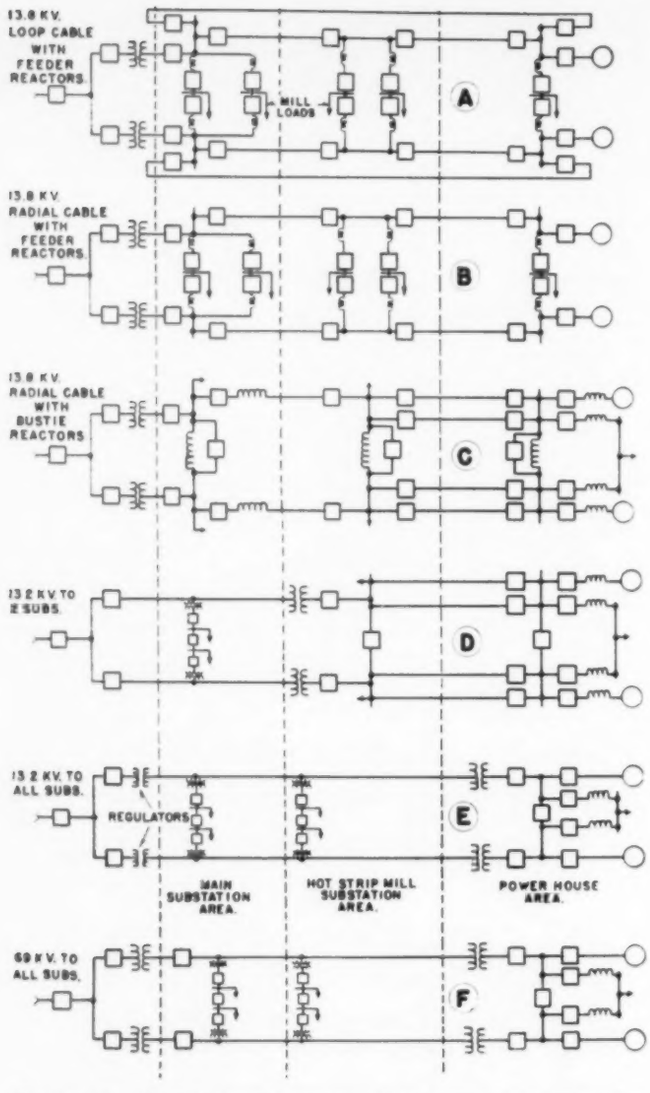



**Figure 10 — Single-line diagrams of six power transmission systems for a fairly large steel plant.**

The authors state that with an existing system it is necessary to recognize the fixed characteristics that exist in the plant. This is extremely true, although the degree with which it controls future expansion varies with the different system changes required. It probably has the least control for major changes when considering the use of a higher voltage for transferring large amounts of power considerable distances within the plant. Also, once a subtransmission system (34.5 kv or higher) is established in the plant, further expansion and the system problems decrease in complexity. Since economics play an important role in system design and indirectly in the complexity of system problems, an economic comparison of six power transmission systems that were considered for a fairly large steel mill is interesting. The study considered new systems in each case, but the results can be used as a guide when considering the use and need of a subtransmission voltage level in existing plants. Details of the study are available in the reference given in the footnote. A one-line diagram of the six systems is shown in Figure 10. The results are in Table IV.

"A-C Power System at the Fairless Works," by S. S. Watkins, L. L. Fountain, W. A. Derr, and R. B. Squires, AIEE Transactions Paper #54-348, Application and Industry, November 1954, pp. 343-352.

**TABLE IV**
**Comparison of System Designs Considered**

| Arrangement | Work-ability | Growth possi-bility | Relia-bility | Cost, per cent |
|---|---|---|---|---|
| A. 13.8 kv loop cable, feeder reactors | Excellent | Fair | Excellent | 192 |
| B. 13.8 kv radial cable, feeder reactors | Good | Fair | Good | 137 |
| C. 13.8 kv radial cable, bus tie reactors | Good | Fair | Good | 124 |
| D. 132 kv to two subs | Good | Good | Good | 114 |
| E. 132 kv to all subs | Good | Excellent | Good | 113 |
| F. 69 kv to all subs | Good | Excellent | Good | 100 |

Messrs. Dalasta and Nolan should be complimented on including all of the important system problems within one paper. Space naturally did not permit a detailed description of the many variations and solutions to each problem, but understanding the general concepts described will certainly permit the steel mill distribution engineer to apply a systematic approach toward obtaining a flexible, reliable, and economic system.

**Howard N. Cox:** Our company built and put into regular operation an a-c network analyzer in 1938 on which approximately 1000 system studies have been made. About ten per cent of these were on industrial systems. So, it is obvious that we are in complete agreement with the authors on the subject of the need for system studies.

The authors mentioned the need for checking the momentary duties on a system, but this point needs additional emphasis. With reference to Figure 4b, look for a moment at the bus having 490 MVA interrupting duty. I presume the authors have already applied the 1.1 multiplying factor for five-cycle breakers to this 490 mva figure; otherwise, the breakers would be applied beyond the 500 mva interrupting rating. The momentary amperes represented by 490 mva of interrupting duty on a 6.9-kv system represents 60,000 asymmetrical amperes. The standard steel mill 7.2 kv switchgear has a momentary rating of 70,000 amperes. This leaves only 10,000 amperes to accommodate the additional momentary amperes which will result when subtransient reactance (typical value—15 per cent) is used for synchronous motor contribution instead of transient reactance (typical value—25 per cent). This 10,000 amperes must also accommodate the induction motor contributions, which are not to be ignored in a steel mill where there is usually a large amount at all voltages. I would appreciate the authors listing the existing loads and explain how the system shown in Figure 4b stays within the 70,000 momentary ampere rating of 7.2-kv switchgear.

I emphasize this point because we have found time and again that 6.9-kv steel mill systems are limited by the momentary rating rather than the interrupting duty.

**M. J. Beaudoin:** At our plant we have a dual radial system that has reached a capacity of 65,000 kva. Reactors were necessary in the branch circuit feeders to limit short circuit currents to a value equal to the rating of the switchgear that they feed. More capacity will be required to take care of our present ex-

pansion. This capacity will be added by additional substations limited to 30,000 kva. They also will be dual radial systems. This method will reduce any power interruption to a smaller portion of the operation, and short circuit capacity to well within the ratings of most standard switchgear.

Steel mill a-c distribution systems can become very complicated and easily grow away from the plant engineer, who does not have the opportunity to be sufficiently versed in this type of a-c problem. Where plants cannot justify the right of personnel, I believe that a power system consultant should be called in to assist in making a complete study, and at this time future expansion plans should be worked out so that it would not be necessary to re-study the system again for at least ten to fifteen years—depending on the amount of expansion that might take place during this time.

To what extent would the authors say the a-c network analyzer has been used on steel mill and comparable power systems?

**Frank Nolan and D. Dalsata:** Mr. Cox's discussion properly suggests that more emphasis could be placed on the circuit breaker momentary duties. High momentary currents impose mechanical stresses on circuit breakers and other electrical apparatus.

Since their contribution to fault currents decays rapidly within the first few cycles, induction motors are considered in the momentary duty calculations but neglected in interrupting duty calculations. Likewise, synchronous motor subtransient values are used for momentary purposes while the higher transient reactance values are used for interrupting duties. The ratio of momentary to interrupting current ratings for all modern power circuit breakers 69 kv and below is about 1.6 under present standards. Since, at these voltages, the momentary duty multiplying factor (Table) for an 8-cycle breaker is also 1.6, one can conclude that whenever motors are present the momentary duty is the limiting factor for 8 cycle breakers (interrupting duty multiplying factor 1.0). However, where modern 5-cycle air breakers are involved it is noted that an interrupting duty multiplying factor of 1.1 enters the picture. The ratio of system momentary duty to system interrupting duty has changed from 1.6:1.0 = 1.6 to the lower value of 1.6:1.1 = 1.45. The 5-cycle air breakers still carry the 1.6 ratio of rated momentary current to rated interrupting current. Thus, while for 8-cycle breakers the momentary ratings are always controlling, for 5-cycle breakers both ratings are more nearly balanced. Yet, it is probably true that, in the average steel mill, the circuit breaker momentary ratings are still the predominant factor.

The mva ratings in Figure 4b to which Mr. Cox refers are symmetrical values based on momentary duties. They thus can be compared directly to circuit breaker mva ratings. Data in this form is more conveniently used in consideration of circuit breaker ratings. Since current alone is the limiting factor in momentary ratings, a suitable correction should be made if the breaker maximum interrupting amperes differs from the interrupting amperes at service voltage.

Mr. Cox suggests the installation of a tie circuit breaker and reactor at each end of the tie circuit of Figure 8. This has many advantages, especially if sources and loads are reasonably well balanced at each end of the mill. The additional installed cost of these devices, however, would be substantial. The radial scheme of Figure 9 would be much less expensive to develop than Figure 8, even without the additional tie circuit breakers and reactors. The system of Figure 9 is acceptable for most mills, since for those infrequent power source failures, tie circuits are available which can be closed promptly.

**TABLE V**

**Table of Multiplying Factors and Machine Reactances to be Used for Calculating Short Circuit Currents for Circuit Breakers**

**Interrupting Duty**

| | 8 Cycles or slower | 5 Cycles |
|---|---|---|
| Circuit voltage | Above 600 | Above 600 |
| System symmetrical mva | 500 or less | 500 or less |
| Multiplying factor | 1.0 | 1.1 |
| Machine reactance | | |
| Generators | $X''_d$ | $X''_d$ |
| Synchronous motors | $X'_d$ | $X'_d$ |
| Induction motors | Neglect | Neglect |

**Momentary Duty**

| | General case | Less than 5 kv |
|---|---|---|
| Circuit voltage | Above 600 | 601–5000 |
| System X/R | More than 10 | Less than 10 |
| Multiplying factor | 1.6 | 1.5 |
| Machine reactance | | |
| Generators | $X''_d$ | $X''_d$ |
| Synchronous motors | $X''_d$ | $X''_d$ |
| Induction motors | $X''_d$ | $X''_d$ |

We are also pleased to have Mr. Beaudoin's comments. They are founded on actual operating experience. He asks about the use of the a-c network analyzer for steel mill and comparable systems. Our experience indicates that at least 10 to 15 per cent of all a-c network calculator studies are on such systems. We note that Mr. Cox's discussion confirms this trend. We agree with Mr. Beaudoin concerning the utilization of power system consultants for complete steel mill a-c distribution studies. We all know that, while broad plans can be made for major plant changes and expansions, the actual modifications never quite turn out to be as expected. Thus, the plant electrical engineer should have intimate knowledge of the details as well as the conclusions of the system studies. This will promote the adoption of periodic system changes which are both economical and well engineered.

Mr. Lokay's discussion is apropos in pointing up the importance of system design studies. The true value of the a-c network analyzer is realized where comparisons of various circuits are essential to determine electrical and economic advantages. His Figure 10, showing the six alternate schemes considered for the Fairless Works with the ultimate adoption of a modified version of scheme F, is a welcome addition to the material presented. He points out that in general the results should be used as a guide only. This is because the studies were made in consideration of the distribution system for a completely new plant as compared to the integrated expansion of an existing mill. The six schemes under study covered a distribution system extending approximately four miles from the purchased power substation to the plant power house. This distance is likely to be less in most mills of similar capacity.

By, FRANK W. ZURN, Vice President, American Flexible Coupling Div., Zurn Industries, Inc., Erie, Pa.

# CROWNED TOOTH

*. . . . crown tooth gear type couplings have design advantages which enable them to solve a number of power transmission problems for the steel industry . . . .*

▲ NOT too many years ago little consideration was given to the problem of connecting rotating shafts. Large massive shafting, loosely mounted in sleeve bearings and joined together by rigidly bolted flanges, was the accepted method. As the tempo of industrial productivity increased, machine designers and operators were awakened to the necessity for flexibly connecting equipment and the advantages of gear type couplings became apparent. Today there are many thousands of applications where the coupling's torque, speed and misalinement capacity, with little or no maintenance attention, has proved its merit in design and cost. To fully understand and appreciate the many advantages of gear type couplings and the improvements made as the result of specialized engineering, a brief review of the desired functions of flexible couplings in general is important.

## DESIRED FUNCTIONS OF FLEXIBLE COUPLINGS IN GENERAL

Flexible couplings are used for coupling together rotating shafts. They transmit torque from one shaft to the other and, at the same time, compensate for misalinement and end movement of the coupled shafts. To achieve and maintain perfect alinement of coupled rotating shafts is practically an impossibility. Essentially true alinement is difficult to obtain in initial assembly or installation and is still more difficult to maintain under continued operating conditions. Settling of foundations, changes due to temperature variations, uneven wear of bearings, dimensional changes in structural members and many other factors make misalinement an operating certainty.

A flexible coupling must then serve three definite functions:

1. Couple shafts for mechanical power transmission, transferring the torque of one shaft to the other, directly and with constant velocity.
2. Compensate for all types of misalinement between the shafts without inducing abnormal stresses and loads on the connected equipment and without a tangible loss of power.
3. Compensate for end or axial movement of the coupled shafts, preventing either shaft from exerting a thrust on the other and allowing each to rotate in its normal axial position.

As there are three basic functions a flexible coupling serves, there are also three basic types of misalinement for which they must compensate. These are:

1. Axes of shafts parallel, but not in same straight line, known as offset parallel misalinement. See Figure 1a.
2. Axes of shafts intercept at point of coupling, but not in same straight line, known as angular misalinement. See Figure 1b.
3. Axes of shafts do not intersect at point of coupling and are not parallel, known as combined angular and offset misalinement. See Figure 1c.

**Figure 1 — There are three types of shaft misalinement.**

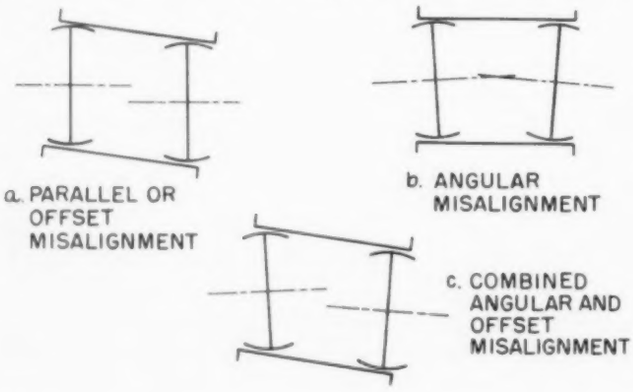
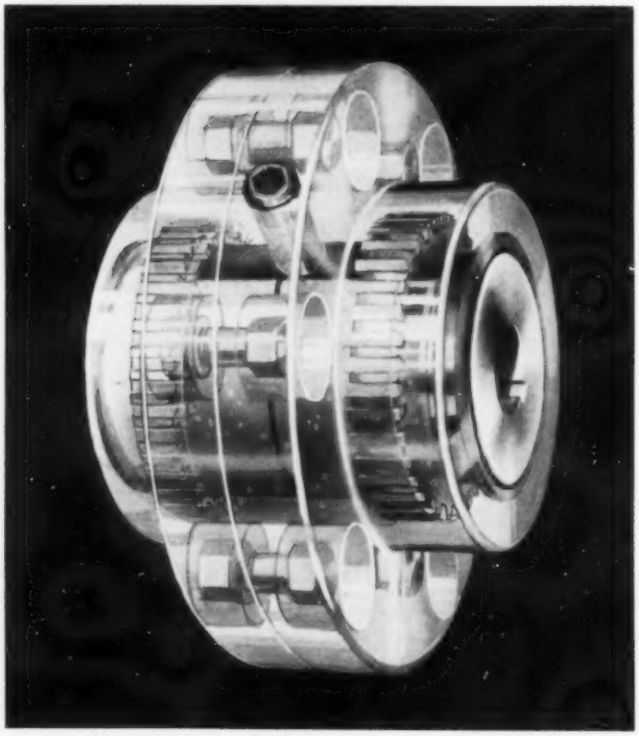



**Figure 2 — Gear type couplings use component parts which slide with respect to one another.**

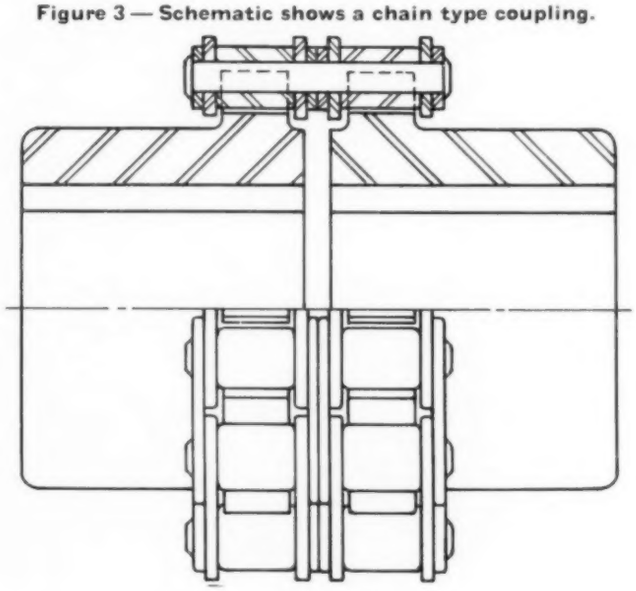


# GEAR TYPE COUPLINGS— Development and Application for the steel industry

The three basic methods by which a flexible coupling can compensate for misalinement are:

1. The use of component parts that slide with respect to each other and do not depend on the flexibility or resilience of the parts for proper operation. Couplings so designed will most fully satisfy the required functions without inducing harmful stresses in the shafts or connected equipment. Gear couplings are of this type. See Figure 2.
2. The use of component parts which fit together loosely and do not depend on the flexibility or resilience of the parts for functioning. Couplings so designed do not transmit torque consistently and are apt to cause erratic strains on the equipment. Chain couplings are of this type. See Figure 3.
3. The use of component parts which are inherently flexible or resilient. Couplings so designed do not transmit torque consistently and require a definite force to flex the material, thus imposing extraneous stresses on the connected equipment and absorbing power. Steel disc, steel grid, steel or rubber pin or bushing, and rubber ball couplings are of this type. See Figures 4, 5, 6, and 7.

Figure 3 — Schematic shows a chain type coupling.



Specifically, a gear type coupling consists of two identical hubs (central members in the exploded view of Figure 8) and a floating sleeve which is ordinarily made in two halves and bolted together to facilitate installation and alinement. These parts are machined to close tolerances generally from steel forgings and castings.

External gear teeth, of numerous designs to be discussed later, are cut integrally on each hub and fully engage ordinary straight-sided internal teeth at opposite ends of the floating sleeve. In order for the coupling to perform its operating function, provision must be made to allow for misalinement between external gear teeth of the hubs and the internal teeth of the sleeve. This is accomplished by unique modifications of the external teeth of the hub.

These unique modifications to the external teeth, and the addition of positive synthetic lubrication seals between the hubs and the ends of the sleeves, are the major design improvements over the past ten years that have contributed to the continuing successful wide usage of gear type couplings.

## EXTERNAL TOOTH MODIFICATIONS, BEGINNING WITH THE ORIGINAL INTRODUCTION OF GEAR TYPE COUPLINGS

*a. The Straight-sided tooth form*—Original gear type couplings and even some manufactured today employ the straight-sided tooth form as shown in Figure 9. The tooth form is produced on shaping or hobbing machines and, in earlier years, was cut with a standard involute tooth profile and 14½-degree pressure angle. In more recent years, a standard involute tooth profile and 20-degree pressure angle have been used. The tooth tip is not crowned, making it necessary to pilot the sleeve and hub on some other related bearing surface to assure good dynamic balance characteristics. (It should be noted at this point that dynamic balance

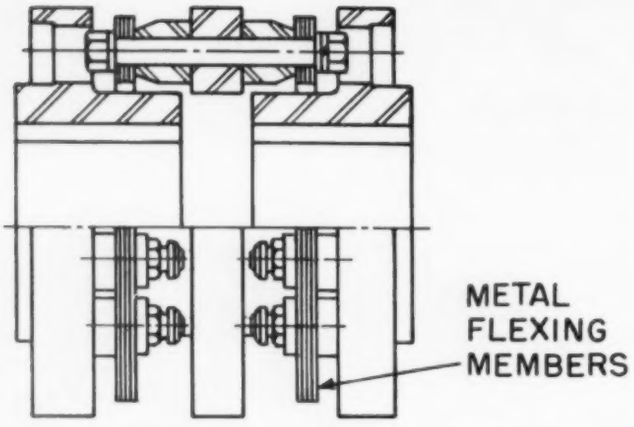



**Figure 4 — Schematic shows disc type coupling with resilient components.**

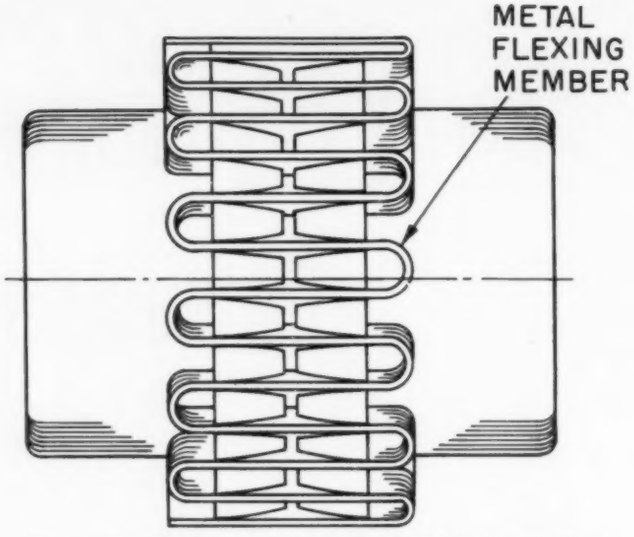



**Figure 5 — Schematic shows steel grid type coupling.**

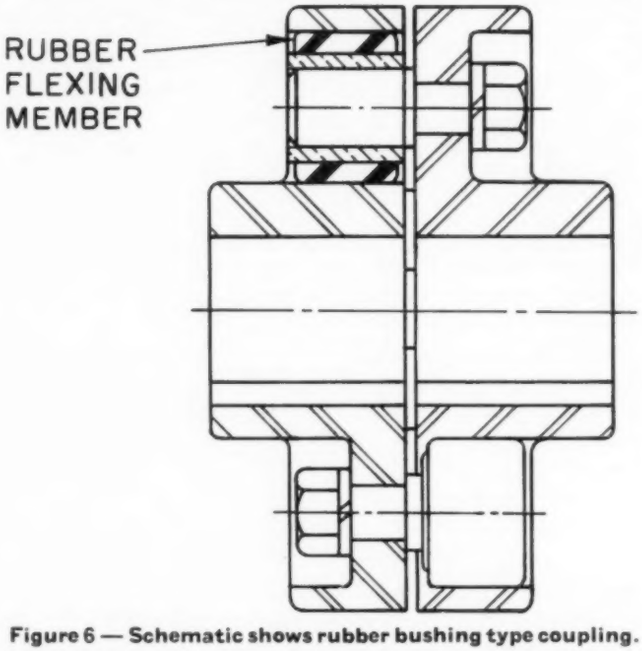
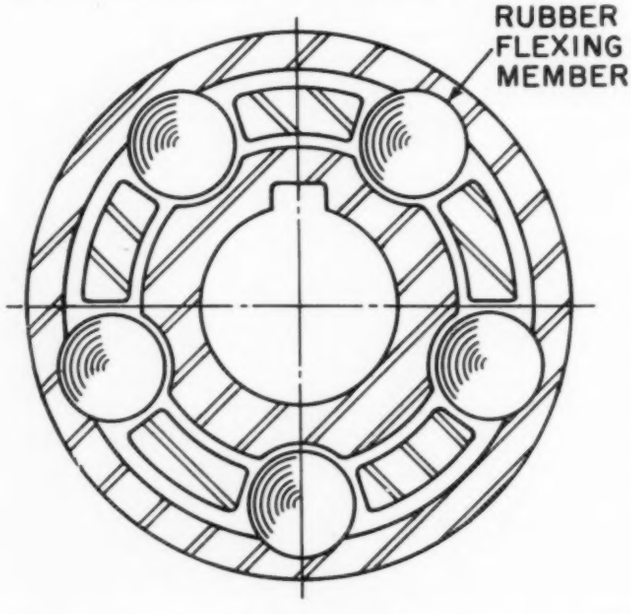



**Figure 6 — Schematic shows rubber bushing type coupling.**

**Figure 7 — Schematic shows rubber ball type coupling.**




characteristics of all gear type couplings are also dependent to a considerable extent upon the pressure angle of the gear teeth, which will cause the sleeve to remain concentric with the hub under certain load and speed conditions, regardless of other related bearing surfaces.)

The major disadvantage with this tooth form is the point of contact on the load bearing surface, known as the flank or face of the gear tooth. As illustrated in the full cycle misalinement pattern (Figure 10) all gear type couplings have relatively few teeth in contact as they compensate for misalinement. Note for the ordinary straight-sided tooth that the point of contact is at the end or weakest portion of the tooth. Only if it were possible to perfectly aline the connected equipment and if machining accuracy of the gear teeth were perfect, would all the teeth be in contact at the same time. Thus end loading of the straight-sided external tooth is the limiting factor of coupling life and is generally the limiting factor of coupling maximum torque capacity. The limits of this tooth contact between the external and internal tooth is known as the Hertz stress, or compressive stress, expressed in terms of pounds per square inch. Therefore, the higher the Hertz or compressive stress, the shorter the coupling life. The basic Hertz equation is $Sc = \frac{\sqrt{P_1 E}}{d}$ for a cylinder on a plane. Here Sc = compressive stress in psi, $P_1$ = linear load per inch of contact, E = 30,000,000 psi for steel and d = diameter of cylinder in inches. Note the only important variable is the contact area expressed as d, the diameter of cylinder, which in the case of the straight-sided tooth, except for slight tooth deflection, is infinitely small, meaning extremely high compressive loading.

To help reduce this loading, lubricant is put inside the coupling; however, the lubricant's effectiveness is also limited by this same compressive stress. In other words, the compressive stresses become so high that lubricant is forced out of the gear meshes allowing metal to metal contact. This results in rapid coupling wear and short life.

It is also important to note that free axial movement between the hubs and sleeves is seriously affected by this compressive loading. As the connected shafts expand or contract in the axial direction, the straight-

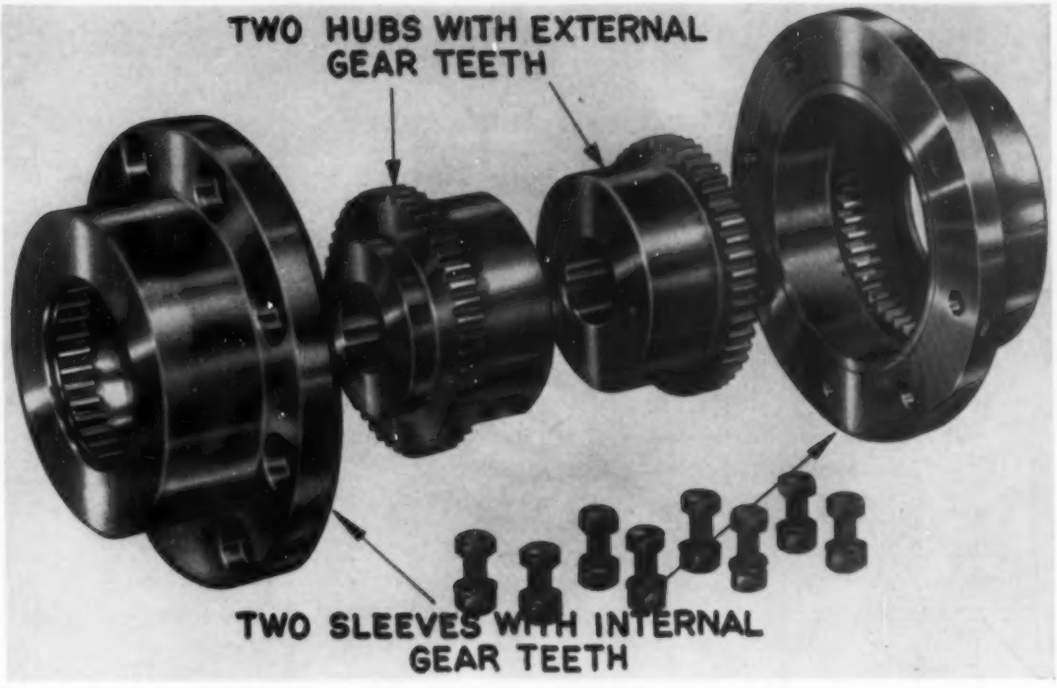



**Figure 8 — Exploded view of gear type coupling.**

sided external tooth digs or gouges into the straight-sided internal tooth, locking the coupling hubs and sleeve as shown in Figure 11, thereby permitting the axial force to be transmitted through the coupling and onto the thrust bearings, limiting their expected life.

When considering initial tooth loading in gear type couplings, tooth bending stresses are quite irrelevant. However, as the hub's straight-sided external tooth begins to wear at its ends due to compressive loading, and the sleeve's internal tooth is gouged out, then these stresses do become important. Eventually, these teeth wear to what is commonly referred to as "knife edges" and become so thin that bending stresses become excessive, causing gear tooth breakage at the roots. Thus the sequence of gear type coupling failure in practically all cases is excessive compressive loading, which in turn causes tooth wear, which in turn causes tooth breakage due to excessive bending stresses.

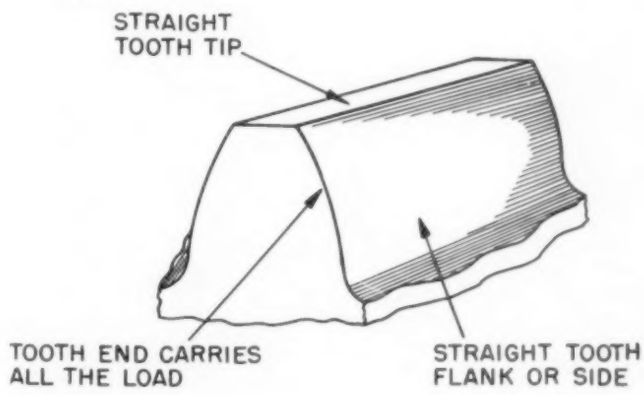
*b. The fully-crowned tooth form*—Contrasted with the straight-sided tooth form, the fully-crowned tooth form shown in Figure 12 is the ultimate known today. Recognizing the inherent design weaknesses of ordinary straight-sided external tooth gear type couplings, the original gear coupling manufacturers developed several versions of improved tooth form, even to the extent of obtaining patents covering a crowned gear tooth shortly after the original introduction of gear type couplings during World War I. Unfortunately, there were no machine tools available to economically produce this crowned tooth, so little consideration was given to its development and application until the mid thirties. At this time, one of the hot rolling mill machinery equipment builders modified a foreign hobbing machine to produce a crowned external tooth gear type coupling. This crowned tooth application was restricted to spindle roll drive couplings where it is necessary to vary roll center-to-center distance and where coupling outside diameter is limited to pinion center-to-center fixed dimensions. In such an application, all the advantages of the crowned tooth were put to the severest tests; namely, high torques in small spaces; high shock loading, high speeds, and varied and fixed operating angles to accommodate varying roll center-to-center distances.

The original crowned tooth was cut with a standard involute profile and 20 degree pressure angle, which is also the accepted standard today. The tooth tip was crowned with a radius equal to the outside radius of the gear blank. In more recent years, the tip has also been chamfered to eliminate interference with the sleeve tooth root fillet radius to allow the true involute flank of the gear tooth to be in contact, particularly when operating at higher misalinements than normally encountered. The tip contacts the root of the internal gear tooth in the sleeve and accurately pilots the sleeve with a ball and socket action, giving the coupling good dynamic balance characteristics, regardless of speed or load conditions.

The fully-crowned tooth has three basic features:

*1. Crowned flank*—This increases the area in contact by eliminating end of tooth loading, with actual tooth loading taking place midway of the tooth face where tooth thickness is greatest. Hertz or compressive

**Figure 9 — Straight type coupling carries load near tooth end.**



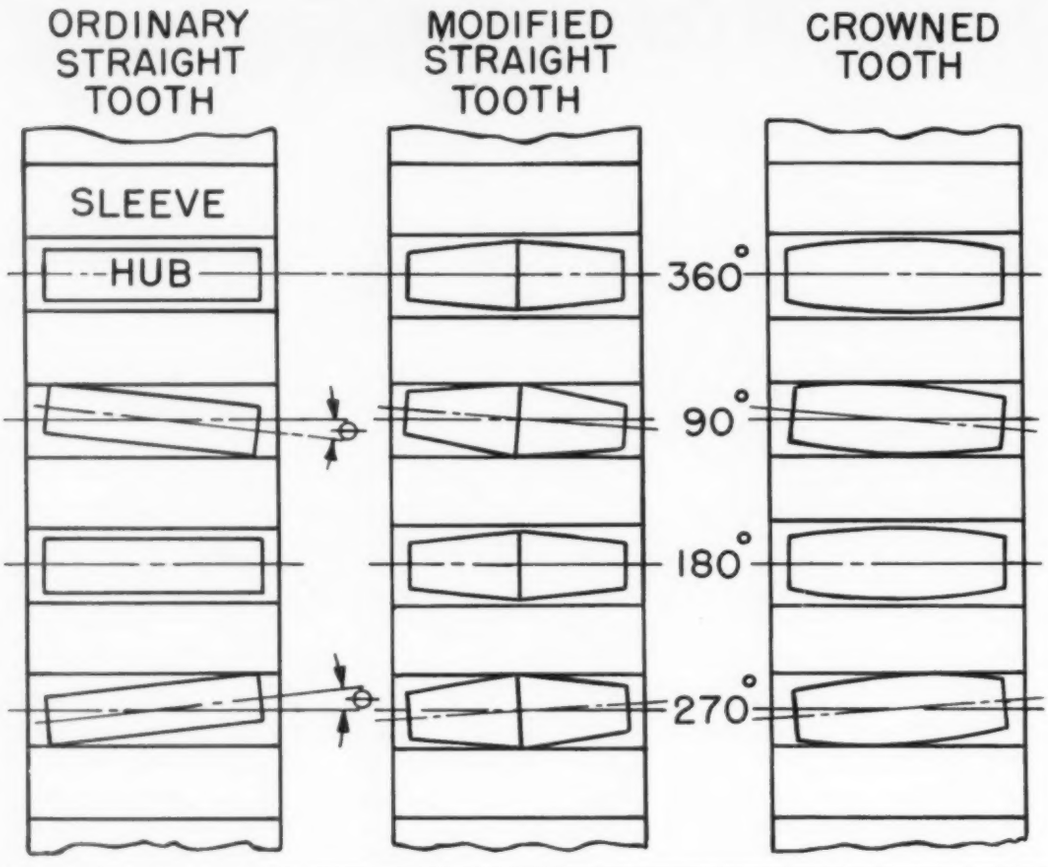



**Figure 10— Sketches show full cycle misalinement patterns for several types of gear tooth couplings.**

stresses are minimized compared with the ordinary straight-sided tooth as the area of contact is sufficiently large to reduce the compressive stresses, which, as explained previously, is desirable and essential to increase coupling load carrying capacity and life.

The crowned flank provides correction for the three types of shaft misalinement up to 3 degree angular for the standard double engagement coupling as compared with 1½ degree angular in ordinary couplings. Angular misalinements up to 12 degrees have been successfully compensated for and even greater misalinement capacity is possible by special combinations of gear meshes. Backlash is kept to an absolute minimum regardless of operating angles.

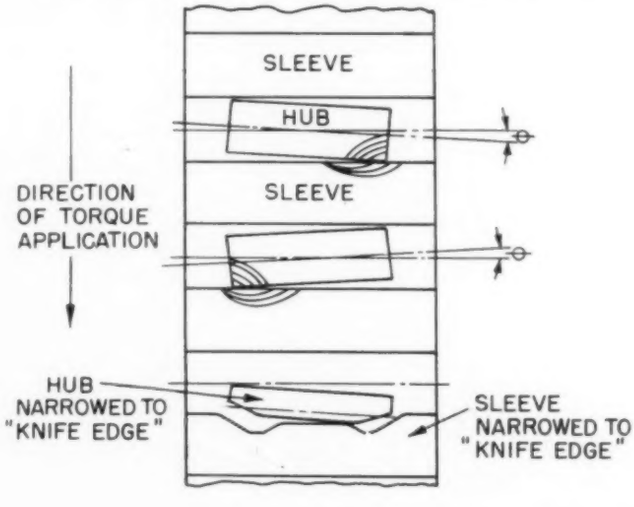
By referring back to Figure 10, note that freedom of axial motion is assured, because digging in or gouging of the internal tooth by the external tooth never has an opportunity to develop with low compressive stresses, preventing "knife edging." In other words, a straight-sided external tooth transmits torque along its end against the internal tooth. The external tooth digs in and eventually locks itself with the internal tooth. On the other hand, the crowned tooth is rounded along its side and has the load spread out across a reasonable area of the tooth flank instead of at the tooth end, behaving much like the curved metal runner of a sled, and is able to slide freely in the axial direction without causing any digging or gouging out of the internal mating tooth.

*2. Crowned Tip*—The tip contacts root of internal gear teeth in sleeve, accurately piloting sleeve with a ball and socket action, thus assuring good dynamic balance characteristics under all operating conditions.

*3. Chamfered tip*—This chamfer eliminates interference with sleeve tooth fillet and allows contact on true flank of gear tooth, regardless of operating angle.

To correct any misunderstandings at this point, it should be mentioned that there is a slight compression of the crowned tooth face under loading, just as there is with the straight-sided tooth. However, because the compression on a straight-sided tooth takes place at its weakest point, namely the tooth end, the combination of high compressive and bending stresses at this point results in comparatively rapid tooth failure. With the crowned tooth, the contact point is located toward the center of the tooth, as shown in Figure 13, so that bending stresses become relatively unimportant. The compressive loading is kept to a minimum by the

**Figure 11 — Compressive loading may cause gouging.**



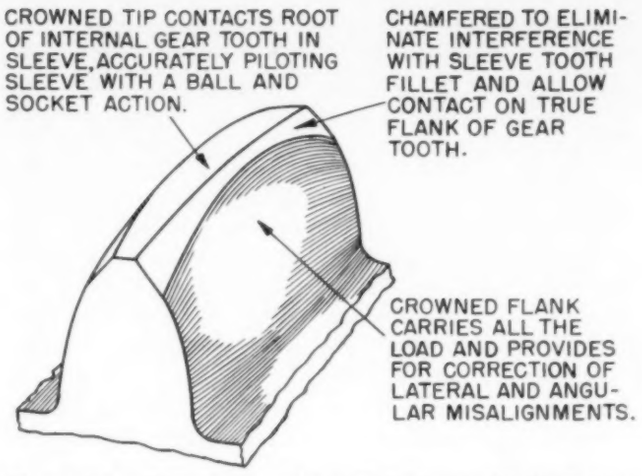

CROWNED TIP CONTACTS ROOT OF INTERNAL GEAR TOOTH IN SLEEVE, ACCURATELY PILOTING SLEEVE WITH A BALL AND SOCKET ACTION.
CHAMFERED TO ELIMINATE INTERFERENCE WITH SLEEVE TOOTH FILLET AND ALLOW CONTACT ON TRUE FLANK OF GEAR TOOTH.
CROWNED FLANK CARRIES ALL THE LOAD AND PROVIDES FOR CORRECTION OF LATERAL AND ANGULAR MISALIGNMENTS.

**Figure 12 — Fully crowned tooth form carries load near middle of tooth.**

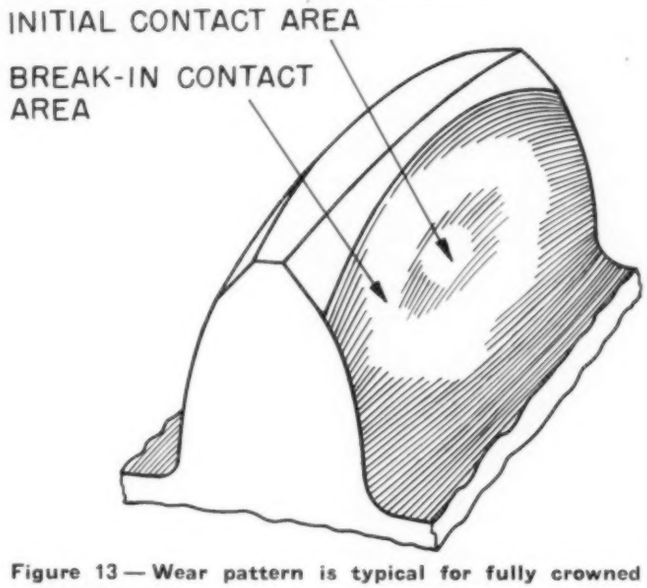



**Figure 13 — Wear pattern is typical for fully crowned tooth.**

crowned tooth behaving much the same as a rubber ball resting on a flat table. When the ball is resting, there is essentially point contact between it and the table. However, when a force is applied to the ball, pushing it down on the table, the point contact is enlarged into an area contact, greatly reducing the compressive loading due to increased area contact.

As with the ordinary straight-sided gear tooth coupling, lubrication is employed to help further in reducing compressive stresses. Its ability to carry out this function is far greater with the crowned tooth as compared with the straight-sided tooth, as evident from prior discussion. In other words, the crowned tooth distributes the loading imposed upon the lubricant across a larger area of lubricant. Further discussion of gear type flexible coupling lubrication follows later in this paper.

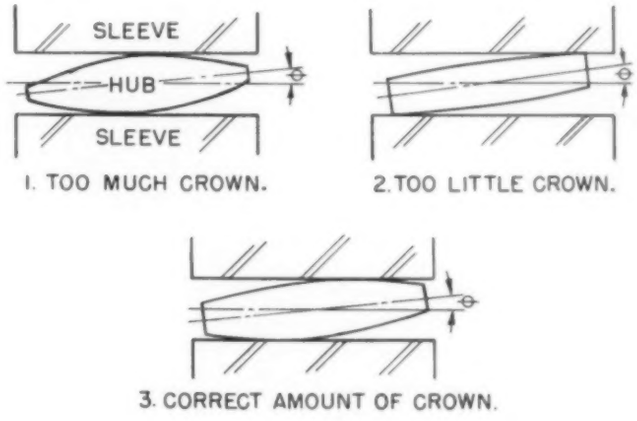
The amount of crown or radius of curvature along the external tooth flank is important to the extent that it is desirable to have just enough crown to give the desired amount of misalinement capacity without end loading, while at the same time keep the area of contact with the mating tooth as large as possible. As shown in Figure 14, too much crown will increase the compressive loading for a given amount of misalinement; too little crown will cause end loading and may even result in mechanical breakage of the tooth by forcing it beyond its maximum misalinement capacity. Certain patents limit crowned tooth coupling manufacturers to various amounts of crowning, depending upon the radius of tooth curvature with respect to the gear blank axis. One patent allows essentially an infinite radius while others are limited to a fixed radius based upon pitch diameter, with the center of curvature of the path of the hob required to be taken at the center of the blank. This results in a satisfactory coupling design for a single case only of load and misalinement. This limitation often results in an amount of crown greater than necessary, thereby reducing tooth area contact. This smaller area of contact increases the compressive stresses, meaning rapid initial tooth wear and shorter coupling life with lower maximum torque capacity for a given sized coupling. The end result is, nevertheless, an improvement in performance over the straight-sided tooth. In summary, the optimum amount of crown should be sufficient to accommodate the desired maximum misalinement of the application without end loading, while at the same time keeping the compressive stresses as low as possible and gear tooth backlash to a minimum.

Hobbing the external crowned tooth has proved to be an accurate and economical method. Recently some manufacturers have gone to the gear shaping process for producing crowned teeth. While patent limitations relating to the fully-crowned tooth form as described earlier also apply to the crown shaped tooth, nevertheless, crowning by shaping is a step in the right direction compared with the ordinary straight-sided tooth form. The major disadvantages of the shaping process as compared with the hobbing process are:

1. Limited crowning due to nature of shaping process causing shaper cutter interference with mating teeth.
2. Limited tooth face width due to limited shaper cutter stroke.
3. Machining accuracies resulting in excessive tooth spacing errors.
4. Slower manufacturing cycle.

Another method of producing a crowned tooth is by crown shaving. This is a two step process involving conventional hobbing or shaping prior to the crown

**Figure 14 — Sketches show effect of various amounts of crown.**

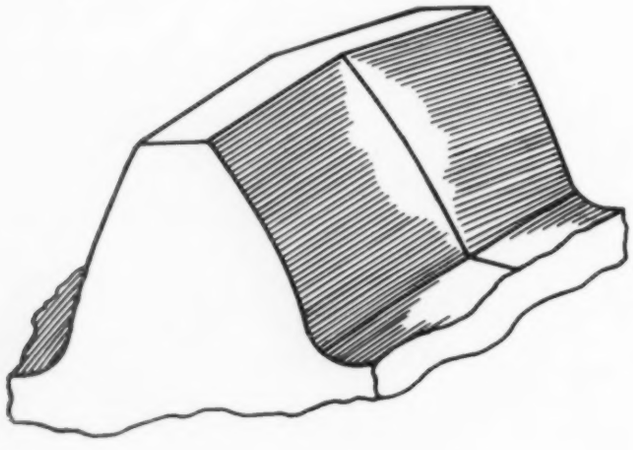


shaving operation and, therefore, costly in comparison to the other methods mentioned earlier. Shaving also limits the amount of crown that can be produced due to shaving cutter runout interference with the next mating external tooth. Where misalinement requirements are not excessive, crown shaving has seen widespread usage, such as in the marine turbine propulsion field. In fact, it has been widely applied over the past fifteen years through U. S. Navy specifications covering propulsion gearing and couplings of all types on turbine driven vessels. Rugged applications of this type have been excellent proving grounds for the superior performance of crowned tooth couplings as against the performance offered by straight-sided tooth couplings.

The distinct advantage of crown shaving is accuracy of tooth spacing that can be achieved following heat treating. Ordinarily, it is not possible to hob or shape gear teeth if the material exceeds a hardness of Rockwell C 38. Thus, if it is desirable to heat treat the gear tooth to high hardness for increased coupling life, it must be done after finish machining, which means distortion can have its effect on final tooth spacing errors. The only way to eliminate these errors effectively after heat treatment is by crown shaving or crown grinding. On high speed turbine and aircraft couplings, shaving and grinding after heat treatment have proved beneficial, although for the thousands of other gear coupling applications, the added costs of shaving and grinding have not proved sufficiently advantageous in achieving the same end results as crown hobbing or crown shaping. Nevertheless, it is important to note that the advantages of crowning the external tooth were recognized by the Navy as far back as the early days of World War II, and many marine propulsion gears, pinions and couplings are still performing satisfactorily today due to the basic fact that the gear elements are crowned.

*C. Modified straight-sided tooth form*—The external tooth form shown in Figure 15 is produced by a hobbing process and has the advantage of offering more misalinement capacity without the inherent weaknesses of the ordinary straight-sided tooth. Ideally, this tooth form offers more area contact than any other tooth form described earlier, if the misalinement angle of the connected shafts is exactly equal to the angle at which the tooth face is relieved. Since it is practically impossible to achieve such an operating condition, the end result is an extremely high Hertz or compressive loading at the center of the tooth caused by the apex of the tooth flank rocking on the internal mating tooth. This high stress concentration causes the mating surfaces to break down, and in a relatively short time the apex wears to a crown. At the same time, the internal tooth is gouged, thus preventing freedom of axial motion between the hubs and sleeve. As the apex wears to a crown, the backlash increases and the resultant damaging effects within the coupling limit its life and usefulness more than desirable compared with the crowned tooth coupling.

**Figure 15 — Modified straight-sided tooth form.**



## EFFECTS OF ALLOY STEELS AND HEAT TREATMENT ON FULLY-CROWNED TOOTH COUPLING TORQUE AND MISALINEMENT CAPACITY

Closely allied with proper gear tooth design, is the metallurgy of the major coupling components. Ordinarily, AISI-1035-1045 steel forgings and castings are found most satisfactory and economical to handle the majority of coupling applications. Various alloy materials or heat treatments will add to coupling life in proportion to the added life attributable to tooth form design improvements. It must be remembered, however, that alloy materials and heat treatment are added costs and unless the coupling application specifically requires high torques and limited space, alloy materials and heat treatment are not necessary. Regardless of material or heat treatment, both the external crowned tooth (hubs) and internal straight tooth (sleeves) are made from the same material and heat treated to the same hardness range. Originally it was thought that a differential hardness between these two members would add to gear coupling life; however, recent laboratory tests and actual field evaluations have disproved this theory.

By referring to Figure 16, it is interesting to note the effects of various alloy steels and heat treatments on torque and misalinement capacity of fully-crowned tooth couplings. Following is a typical example of how approximate gear tooth proportions are obtained that will transmit 78,000 in.-lb. of torque under a misalinement of 3 degrees.

1. Locating 78,000 in.-lb at the left of the chart, move horizontally until the 3-degree misalinement curve is intersected.

2. Move down in a straight line, intersecting the slanted lines located along the lower edge of chart.

3. Under 78,000 in.-lb and 3-degree misalinement conditions three straight lines are intersected at bottom of chart, namely,

*a.* In area immediately above base line indicating gear tooth proportions of 1.125 face, 8.000 pitch diameter and 8 D.P. with material specification of AISI-1045 annealed.

*b.* In first section below base line indicating gear tooth proportions of 1.000 face, 6.900 pitch diameter and 10 D.P. with material specification of AISI-1045 heat treated to 25–30Rc.

*c.* In third section below base line indicating gear tooth proportions of 0.875 face, 6.000 pitch diameter and 10 D.P. with material specification of AISI-8620 carburized and heat treated.

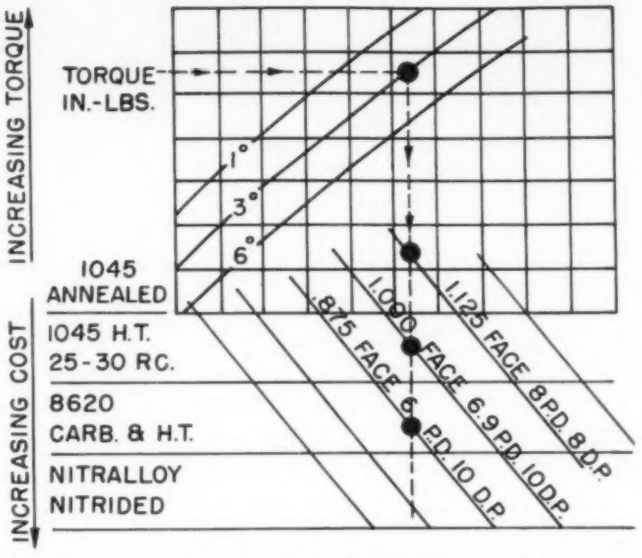



**Figure 16 — Gear tooth proportions are affected by materials used.**

Any of the three tooth proportions mentioned in (a), (b) or (c) will be satisfactory for this application.

No doubt in the years ahead an increasing number of gear couplings will be furnished from alloy steels and heat treated, due to mill machinery design requiring higher speeds, smaller space and longer continuous operating periods between shutdowns, but present standardization of gear coupling flange, bolt circle and bolt dimensions will delay this trend until coupling manufacturers establish new realistic standards based on improvements in basic design and material during the past 35 years.

## REVIEW OF THE PAST HISTORY OF GEAR COUPLING LUBRICANT RETAINERS AND PRESENT DAY SEALS

Beside modifications to the hub gear tooth, another important improvement in gear coupling design in the past decade has been the introduction of synthetic hub seals for positive retention of lubricant, and the prevention of lubricant contamination by moisture and foreign matter present in the surrounding environment of the coupling. Improvements in seal design have been as beneficial to the advancement of self contained, lubricated and sealed automatic transmissions in modern automobiles, or advancement in self contained and sealed bearings in industry. The less concern there is on the part of operating and maintenance personnel about the necessity of having to lubricate couplings frequently due to loss and contamination of the lubricant, is so much the better.

**TABLE I**

**Location and Prevention of the Four Sources of Coupling Lubricant Leakage or Contamination**

| Location of leakage or contamination | Prevention of leakage or contamination |
|---|---|
| 1. Between hub and sleeve | 1. Efficiently designed synthetic seals |
| 2. Between sleeve flanges | 2. Synthetic flange gasket and caution not to damage rabbet or face of flange |
| 3. Lubricant filling plugs | 3. "Dryseal" type lubricant plugs or socket head cap screw with gasket |
| 4. Clearance between key and keyway on shaft and coupling hub | 4. Coat keyways and keys with permatex or similar lubricant resistant sealing compound at assembly |

When properly installed, and by using efficient positive synthetic seals, the coupling is essentially a dust and moisture proof unit. However, if improperly installed by overlooking the four sources of lubricant contamination or leakage outlined in Table I, coupling life can be appreciably shortened.

*a. End plate labyrinth type lubricant retainer*—When gear type couplings were first introduced, there was no synthetic positive seal available that could withstand repeated flexing motion between hub and sleeve, nor the deterioration caused by the lubricant. Thus, as shown in Figure 17, the all metal labyrinth type end plate with its center of contact in line with the center of the gear meshes was a good alternate.

However, because of the clearance necessary between the hub and sleeve to accommodate misalinement, positive retention and protection of the lubricant from outside contamination is impossible. Whenever the coupling is stopped, such as in reversing applications, or during machinery shutdown, a certain amount of lubricant leaks out of the clearance between the hub and the sleeve. In past practice prior to development of satisfactory grease lubricants, lubricating oil was added as frequently as once a week, and generally an oil pan was installed below the coupling to keep the surrounding area and equipment clean from dripping coupling oil. The difficult and out-of-the-way locations where couplings are often installed due to the very nature of steel mill equipment design, caused prematurely worn-out couplings due to lack of lubricant simply because lubrication personnel could not readily or frequently get to the coupling to add lubricant.

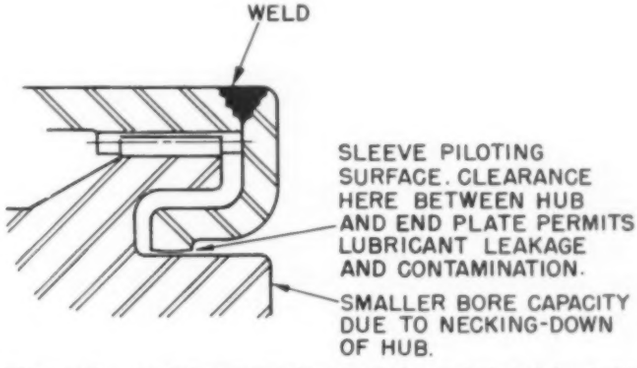

WELD
SLEEVE PILOTING SURFACE. CLEARANCE HERE BETWEEN HUB AND END PLATE PERMITS LUBRICANT LEAKAGE AND CONTAMINATION.
SMALLER BORE CAPACITY DUE TO NECKING-DOWN OF HUB.

**Figure 17 — Lubricant retainer is of the end plate labyrinth type.**

Equally as much of a disadvantage caused by loss of lubricant with this type of retainer is the fact that even though the equipment may rotate in one direction for extended periods without shutdown, contamination of the lubricant by moisture and foreign matter has proved to be a limiting factor in coupling life. Even with carefully designed coupling cover guards, contaminated air and moisture work into the coupling interior between the sleeve and hub clearance.

This type of lubricant retainer also imposes problems during manufacture of the sleeve. It is impossible to cut the sleeve's internal gear teeth by gear shaping or broaching with the end plate in position. Therefore, it is necessary to attach the end plate after producing the internal gear teeth. The most economical method is by welding, which has proved reasonably satisfactory, although weld porosity has caused lubricant loss and end thrust of the hub against the sleeve has caused breakage of the end plate apart from the sleeve.

This design imposes a further disadvantage in that the bore capacity of the hub is limited due to the hub outside diameter being limited by the inside diameter of the sleeve end plate. This deep reduction of hub outside diameter so that the end plate can be centered on the gear mesh, limits the bore capacity by an average of ½ to ¾ in. compared with other gear couplings. Therefore, in most installations, a larger coupling must be used than is actually necessary to meet the maximum torque conditions, resulting in larger shaft overhanging loads and higher initial coupling cost. In high-speed applications, where it is extremely desirable to keep shaft overhanging weight to a minimum, the larger coupling also presents a critical dynamic balance problem due to its added weight.

Couplings employing this type of lubricant retainer depend for good dynamic balance characteristics upon sleeve piloting in relation to the hub, by the limited clearance of the outside diameter of the hub and the inside diameter of the sleeve end plate, rather than hub gear tooth tip and sleeve tooth root clearances with couplings using synthetic seals.

*b. Synthetic "O" ring type positive lubricant seals*—The "O" ring type seal shown in Figure 18 was developed by the Air Force during World War II and is now a common item in steel mill hydraulic and mechanical equipment. Most major pieces of steel mill machinery requiring lubrication use "O" ring seals, and their efficiency in retaining lubricant and preventing its contamination in gear type couplings has proved most successful. Because "O" rings have a circular cross section, any pressure applied, such as that caused by motion of the hub in relation to the sleeve through misalinement, is equally distributed radially in all directions across the seal, thereby reducing the possibility of permanent set of the seal.

Synthetic neoprene "O" ring seals are designed to accommodate up to 300 F temperatures. In a few installations—such as soaking pit covers or hot ladle cranes—couplings, as well as gear reducers, electric motors and line shaft bearings are shielded to prevent direct exposure to continued high temperatures. If temperatures higher than 300 F are anticipated for any length of time, silicone or teflon "O" ring seals can be successfully used up to 500 F.

Other advantages of "O" ring seals are their simplicity and ready availability from most local mill supply houses. They can be installed without removing the coupling hub and sleeve from the shafting, an important detail should it ever become necessary to replace after installation, since they can be stretched over the outside flange of the coupling sleeve or hub and then seated in the sleeve seal groove.

Should blow torches be used in heating the coupling

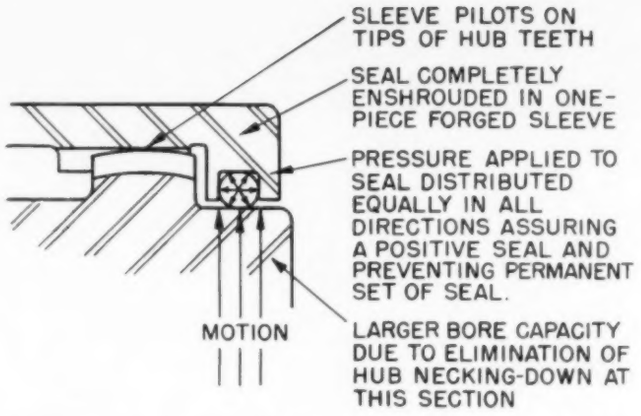
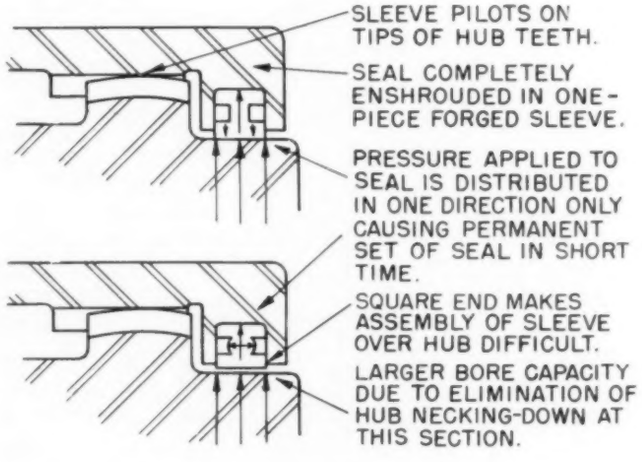

SLEEVE PILOTS ON TIPS OF HUB TEETH
SEAL COMPLETELY ENSHROUDED IN ONE-PIECE FORGED SLEEVE
PRESSURE APPLIED TO SEAL DISTRIBUTED EQUALLY IN ALL DIRECTIONS ASSURING A POSITIVE SEAL AND PREVENTING PERMANENT SET OF SEAL.
MOTION
LARGER BORE CAPACITY DUE TO ELIMINATION OF HUB NECKING-DOWN AT THIS SECTION

**Figure 18 — The synthetic "O" ring type positive lubricant seal has many advantages.**

hub prior to shrinking it onto the shaft, there is the possibility of burning up the synthetic seal, unless care is taken to place the sleeve with the seal well back onto the shaft overhang, or else removing the seal and installing it after shrinking on the hub. The dangers of using such equipment in and around expensive machinery, and the fact that coupling parts can be seriously damaged by improper heating with a blow torch, have caused maintenance personnel to abandon such practice.

*c. Synthetic "H" or "T" cross-section type lubricant seals*—The seal shown in Figure 19 was introduced several years before the "O" ring type seal, and while it has performed better than other synthetic seals used before "O" rings, it, nevertheless, has several disadvantages which limit its acceptance. Due to the fact that it has a rectangular cross section in its thinnest portion, it tends to take a permanent set in a relatively short time because any pressure applied, such as that caused by motion of the hub in relation to the sleeve through misalinement, is distributed in one direction across the narrow portion of the seal rather than being equally distributed in the case of "O" ring seals. This permanent set permits the lubricant to flow out of the coupling. Equally detrimental to coupling life, dirt and contamination of the surrounding atmosphere are allowed to enter the coupling, causing

**Figure 19 — Cross section of synthetic "H" or "T" lubricant seal.**


SLEEVE PILOTS ON TIPS OF HUB TEETH.
SEAL COMPLETELY ENSHROUDED IN ONE-PIECE FORGED SLEEVE.
PRESSURE APPLIED TO SEAL IS DISTRIBUTED IN ONE DIRECTION ONLY CAUSING PERMANENT SET OF SEAL IN SHORT TIME.
SQUARE END MAKES ASSEMBLY OF SLEEVE OVER HUB DIFFICULT.
LARGER BORE CAPACITY DUE TO ELIMINATION OF HUB NECKING-DOWN AT THIS SECTION.

the lubricant to become contaminated and to fail in the performance of the function for which it was originally placed in the coupling.

Another disadvantage of this type of seal is the fact that it is difficult to assemble the sleeve over the hub because the engaging corner of the seal is a right angle as compared to the curved engaging surface of the "O" ring type seal.

Finally, this type of seal is not available in local mill supply houses and must be obtained from special factory sources or direct from the factory. It cannot be stretched over the coupling sleeve flange and installed after the coupling has been mounted on the shaft, which means added downtime should the coupling seal be damaged in any way during installation, or the conditions of assembly be similar to those included in the "O" ring discussion.

*d. Other synthetic type lubricant seals*—Other cross sections of various types of synthetic seals that have been successfully applied in gear type couplings are shown in Figure 20. Each seal has its own specific use; however, when applied to ordinary coupling applications, these seals all mean added cost. Should excessive misalinements be contemplated in a particular coupling application, then it is necessary that these special type seals be incorporated. Regardless of which seal is finally selected for high misalinement applications, the important point to remember is that a means should be provided for protecting the seal on those surfaces exposed to any mechanical motion. In other words, the seal shown in Figure 20a will have a limited life due to the fact that the outside ends of the hub teeth come into physical contact with the inside end of the seal, whereas the metal shrouding protecting the inside end of the seal from this contact, as shown in Figure 20b, will prevent the seal from ever becoming damaged.

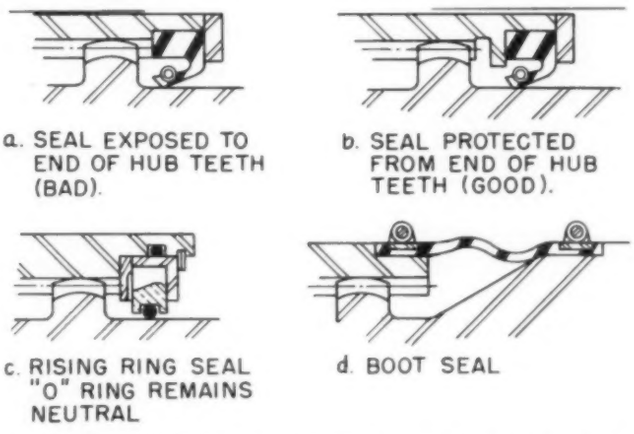

a. SEAL EXPOSED TO END OF HUB TEETH (BAD).
b. SEAL PROTECTED FROM END OF HUB TEETH (GOOD).
c. RISING RING SEAL "O" RING REMAINS NEUTRAL
d. BOOT SEAL

**Figure 20 — Sketches give several typical seals for high misalinement applications.**

One of the most popular seals in existence today for higher misalinement applications is the "rising "O" ring type seal" as shown in Figure 20c. With this type of seal, the "O" ring never has any uneven forces applied to it, thereby always maintaining good contact on the coupling hub, with all relative motion taken between the metal backing ring and groove. By careful design, any lubricant trying to escape through the clearances between the metal backing ring and groove is continuously pumped back into the coupling. Contamination and foreign matter in the atmosphere are unable to enter the coupling due to the fact that a protective lubricant film is always maintained between the backup ring and groove.

Numerous other types of seals have been developed for specific applications, including a variety of boot type seals in use today on extremely high misalinement capacity coupling installations, as shown in Figure 20d.

In summarizing the subject of synthetic lubricant seals, there is no doubt that their advantages far outweigh any disadvantages they might have, and with the development of efficient synthetic seals such as the "O" ring type, it is possible for gear type couplings to be installed today, grease lubricated and left to operate for periods of at least three to five years before any maintenance or lubricant addition is required. This is particularly true of crowned-tooth gear type couplings offering misalinement capacities up to 3 degrees, for the only other reason to stop and check the interior of a gear type coupling is to check the alinement. With couplings offering only 1½-degree angular misalinement capacity, the necessity to stop and check equipment alinement is far more frequent than with 3-degree misalinement capacity couplings. If maintenance personnel are going to go to the trouble of disassembling the coupling to check misalinement, then it is also a good time to fill the coupling with fresh lubricant. Positively sealed couplings, therefore, are much the same as positively sealed motors and bearings, in keeping with today's trend toward more positively sealed rotating machinery. The high maintenance costs of equipment without this feature, and conversely the fewer number of times mechanical equipment has to be disassembled in the field when this feature is utilized, particularly in steel mill environments, are clear cut benefits that attest to the desirability of positive sealing.

## LUBRICATION OF GEAR TYPE FLEXIBLE COUPLINGS

There is no one lubricant that is best for all operating conditions, as each installation has its particular problems. Therefore, operating personnel should choose lubricants with as broad characteristics as possible.

For many years oil was used exclusively in gear type couplings; however, during the past ten years improvements in greases have been so great that practically all lubricated couplings today standardize on greases in place of oil wherever possible.

Coupling manufacturers specify numerous lubricants for use in their couplings and always allow for equivalent lubricants to those listed. As such, coupling manufacturers accept responsibility for performance of lubricants when specified. However, it is wise to use lubricants already in use at a given mill if possible, not only to avoid complications of stocking problems, but also to reduce the possibility of contamination by the wrong lubricant by mistake, for all lubricants are not compatible. Coupling manufacturers cannot possibly know all about every lubricant available, but through research and development, field testing and co-operation of grease manufacturers, many suitable types are readily available today.

Heat is the lubricant's worst enemy for it accelerates oxidation (formation of sludge) and reduces the viscosity (lubricant film thickness) and, therefore, load carrying ability. Heat generated in a coupling depends upon the load, speed and misalinement present, for these add up to friction losses within the coupling. The greater the sliding of the teeth, and the faster this happens (increased speed), the more heat is generated.

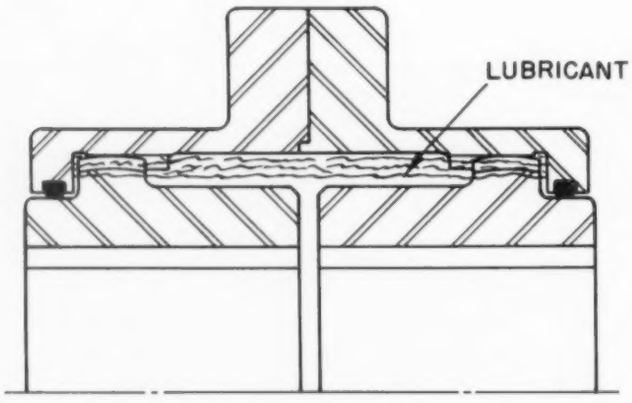
In most applications where coupling operation is kept within catalog rating, heat generation is sufficiently low so that the natural cooling of the coupling rotating in air keeps temperatures within bounds. In cases of high misalinement (above 3 degrees per mesh, or 6 degrees for the double engagement coupling) and/or high speeds, the rate of heat generation may exceed the rate of heat dissipation with the resultant failure of the lubricant and the coupling. Where it is difficult to increase the rate of heat dissipation, it is important to tailor the lubricant to the conditions to control heat by achieving the lowest coefficient of friction possible. Problems of this kind should be referred to the coupling manufacturer or any reliable lubricant manufacturer for recommendations.

Grease is used in the bulk of coupling applications today, and most coupling manufacturers producing couplings requiring lubrication recommended grease wherever possible because of its freedom from leakage, low servicing cost and long life. If a coupling is overfilled with grease, some will be forced out of the coupling between the seal and hub due to mesh action, or the coupling will overheat. If the coupling is filled to about two or three times the height of the sleeve teeth while running, and if it is not one requiring cooling, one filling of grease will last in the ordinary case, from three to five years before additional grease is required, provided positive lubricant seals are used.

Oil as a lubricant in gear type couplings is used today only in one of three ways, as follows:

*1. Single charge* (*Figure 21*)—The standard method is to put enough oil into the coupling so that when running at service speed the radial depth of the layer of oil thrown out against the sleeve is something more than the height of the sleeve teeth. This would be ideal were it not for the risk of leakage and contamination due to no positive seals, either by nature of the coupling end plate design or inefficient seals.

**Figure 21 — Single charge lubrication is ideal where leakage or contamination is not likely to occur.**




*2. Continuously lubricated—a. Without dams* (*Figure 22a*)—These couplings have an oil jet directed into the sleeve teeth which circulates oil continuously for lubrication and cooling. The distribution of oil is often not good, however, because the oil escapes through gear tooth backlash space before it can lubricate the teeth some distance from the oil supply port.

*b. With complete dams* (*Figure 22b*)—Except for dams supplied at the ends of the sleeve teeth, this type is similar to that without dams. Oil distribution is improved, but sludge and foreign particles are centrifuged from the oil, gather in the sleeve teeth and eventually cause trouble.

*c. With partial dams* (*Figure 22c*)—Here spaces are left under the simplified snap ring dams to permit partial loss of oil. So long as the supply is in excess of the loss through these spaces, the situation is improved because foreign matter can be flushed out while maintaining an adequate supply of clean oil on the teeth. This method has proved most satisfactory in high-speed applications such as blast furnace turbine blowers.

*3. Intermittently lubricated*—This is similar in design to Figure 22b, but the oil supply is not continuous. By filling the coupling to the top of the dam (while running), then turning off the oil supply for a period of time and then refilling again, either manually or automatically, less oil circulates through the teeth in a given length of time and correspondingly less foreign material is trapped within the coupling gear meshes. Where cooling is essential, however, this method cannot be used.

In summarizing, it must be kept in mind that a flexible coupling depending upon oil lubrication, either by the continuous or intermittent method, behaves exactly like a centrifuge, and all foreign matter present in the circulating oil, no matter how carefully it may be filtered, is going to be retained in the coupling unless means are provided for flushing this contamination from the coupling gear teeth. That is why the partial dam, as described in Figure 22c above, has proved so successful and is preferred particularly in high speed continuous lubricated coupling installations.

## BALANCING OF GEAR TYPE FLEXIBLE COUPLINGS

Commercial gear type couplings applied at speeds below 5000 rpm do not, ordinarily, require special balancing. As speeds increase, or supporting structures become lighter, however, damaging vibrations may occur that can be prevented only by careful balancing of the components of the system. The technical analysis of the balancing operation is a subject by itself and, therefore, will not be discussed in detail in this paper. Suffice to say, most gear type coupling manufacturers have established standards for dynamic balancing tolerances and attempt whenever possible to produce a coupling with good balance characteristics. Because of the concentric design of the parts making up gear type flexible couplings, good dynamic balance is inherent in the final coupling assembly. In steel mill installations, generally the only place coupling dynamic balancing is required is on high speed turbine blower drives.

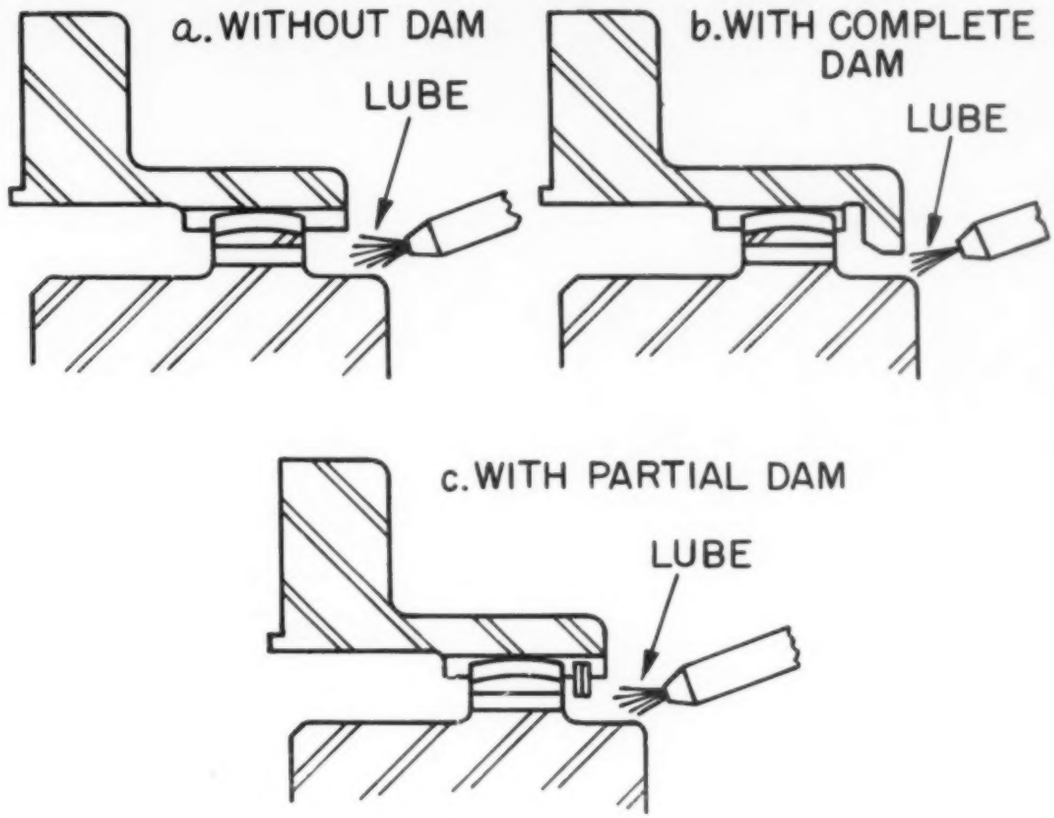



**Figure 22 — Several schematics for continuous lubrication of couplings are shown.**

## SOLUTION OF DIFFICULT OPERATING PROBLEMS WITH FULLY-CROWNED TOOTH GEAR TYPE COUPLINGS

Acceptance of the fully-crowned tooth gear type coupling by industry in general was not accomplished overnight. Straight-sided tooth gear type couplings had been operating for a number of years, doing a limited satisfactory job. Therefore, to gain acceptance in the shortest possible time, fully-crowned tooth couplings were first applied to solving those difficult applications which could not be handled by the straight-sided tooth. Because the type of coupling problems solved with the fully-crowned tooth couplings were so much more difficult compared with limited applications of straight-sided tooth couplings, industry began to recognize that the fully-crowned tooth coupling offered practically unlimited potential as a source of trouble free mechanical power transmission, regardless of application. The following paragraphs cover typical difficult application problems satisfactorily resolved with fully-crowned tooth couplings.

*Problem No. 1*—Minimum backlash to permit accurate fire control of U. S. Navy twin 3-in. 50 gun mount, the main anti-aircraft gun mount on major ships in the U. S. fleet today. There are three fully-crowned tooth gear type couplings installed horizontally in the elevating drive mechanism, and three fully-crowned tooth gear type couplings installed vertically for horizontal gun mount rotation. Prior to design of this new gun mount after World War II, earlier gun mounts had been equipped with steel disc type couplings which were selected because they supposedly required no maintenance and had very little backlash, which latter condition was important for fire control accuracy. However, when put into combat service during the initial months of World War II, the disc type couplings often fatigue failed because of repeated reversing loads caused by continuous rapid elevation and rotation of the gun mounts. Therefore, it was imperative that these couplings be replaced, and the U. S. Navy recognized that a gear type coupling could do the job better than the disc type coupling, except for inherent backlash and lubrication requirements. As a result, many thousands of straight-sided tooth gear type couplings were supplied with limited misalinement capacity to keep backlash controlled to a minimum. Throughout the remainder of World War II, the design deficiencies of straight-sided tooth gear type couplings in this application became apparent, even though they outperformed disc type couplings.

At the end of World War II, the U. S. Navy prepared a new general specification for gun mount drive couplings, with no reference to type of coupling. After several years of navy laboratory and field testing, gear type couplings furnished with the fully-crowned tooth and positive lubricant seals, were the only couplings able to withstand the repeated reversing torque loads, accommodate the misalinement requirements, and still control backlash to within a minimum allowable range.

*Problem No. 2*—High misalinement capacity was needed for traction motor drive units in the small space for subway and multiple-unit railway cars. A fully-crowned tooth gear type coupling is now used connecting the electric traction motor with gear box and wheel. Because of the design advantages of this fully-crowned tooth gear type coupling, and by means of specially designed positive lubricant seals, several thousand of these couplings have been used in subway

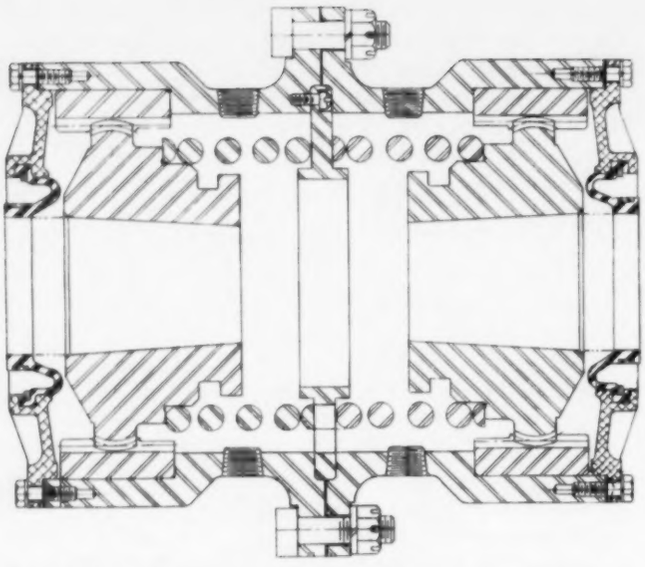


**Figure 23 — This coupling was designed for traction drive.**

and multiple unit car drives, eliminating the need of inefficient universal joints and costly right angle gear boxes used in previous designs. The couplings transmit approximately 100 hp, operate at speeds up to 4000 rpm and, depending upon passenger loading, accommodate angular misalinements up to plus or minus 5½ degrees (11 degree total) and also permit ⅝-in. axial shaft movement. The application involves sudden stops and starts, and torque reversals.

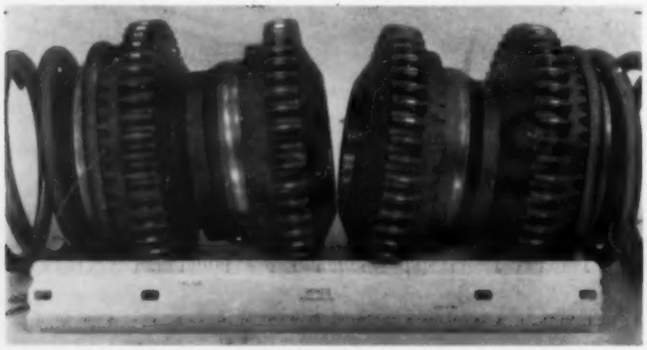
A cross section drawing of the traction drive coupling is shown in Figure 23. Two centering springs keep the sleeve centered during high misalinement conditions, preventing thrust loading of the aluminum cooling type end plates.

Figure 24 shows the wear pattern on some traction coupling hubs after more than three years operation. Note the exceptionally good wear characteristics in center portion of the crowned tooth face where full tooth beam strength is utilized, and also that during no-load operation, such as coasting, the coupling sleeve remained concentric with the hubs by evidence of polish on tooth tips, meaning good dynamic balance regardless of speed or operating angle.

*Problem No. 3*—High misalinement capacity alternating current traction motor drive unit in small space for multiple-unit railway cars.

In other applications of the type described in Problem No. 2, the power source is 25 cycle a-c. The torque pulsations produced by this alternating current cause severe stresses in the motor armature and high speed gear box shafts. To reduce these stresses to a safe amount, a bonded rubber "sandwich" is incorporated in the sleeve construction. To protect the rubber from damage during peak torque in overload conditions, safety lugs between the sleeves limit the amount of deflection in the rubber to a safe value. Here is a unique combination of the fully-crowned tooth to accommodate angular and parallel misalinement by mechanical design, while at the same time making use of a torsionally soft material for the purpose of dampening out severe torque pulsations. (Other fully-crowned tooth couplings of this design incorporate rubber elements for purposes of sound isolation, dielectrics to stop stray currents and dampening out severe torque pulsations common in direct drive diesel engine drives.)

**Figure 24 — Typical wear patterns on traction drive gear couplings.**



*Problem No. 4*—Light weight, compact and safe mechanical power transmission between engine, rear and forward rotor gear boxes with ability to accommodate 5-degree angular fuselage flexure.

Following the successful application of fully-crowned tooth couplings on Navy gun mounts, subway and multiple unit railway cars, they were next applied in large tandem rotor helicopters. In this application, the fully-crowned tooth couplings accommodate up to 5-degree flexure of the helicopter fuselage between the two rotors during varying payloads and wind conditions. The weight of the fully-crowned tooth couplings is approximately one third less than universal joints which had been used in previous helicopter designs, and the fully-crowned tooth couplings occupy approximately half the space of universal joints.

*Problem No. 5*—A synchronizing clutch for nuclear powered submarines which can engage and disengage under high torque loads in short time intervals.

The synchronizing clutch used on nuclear powered submarines, combines a disc type clutch to synchronize the main propulsion drive shaft and a double engagement fully-crowned tooth coupling to accommodate shaft misalinements after synchronization. The crowned tooth permits free axial sliding of the coupling outer sleeve during engagement and disengagement under load without damaging effects of gouging or digging, which would result with the ordinary straight-sided tooth. Also, the fully-crowned tooth permits extremely high torque transmittal in a relatively small space.

The unusual and difficult coupling applications just described have their parallel in all types of steel mill drives. These include:

1. The fully-crowned tooth coupling is ideally suited for screw-down drives due to its limited backlash compared to the straight-side tooth, just as in the case with Navy gun mount elevating and rotating drives. It is also ideal for reversing mill table roll drives and runout table roll drives, where it is desirable to keep backlash in the coupling to a minimum so that shock loading will not be transmitted through the driving mechanism, resulting in severe shaft and pinion stresses, or breakage of coupling teeth.

2. The application in subway cars, where space is at

a premium and high misalinement necessary to accommodate fluctuating loads, has its parallel in the steel industry in the application of fully-crowned tooth couplings for driving work or backup rolls on all types of rolling mill machinery in place of heavy, bulky, universal slipper and wobbler type couplings.

3. The helicopter application parallels the typical steel mill crane in that the entire crane bridge deflects under varying loads as it travels along uneven crane supporting tracks, meaning couplings must be properly designed to safely accommodate the flexure.

4. The nuclear powered submarine synchronizing clutch couplings have their parallel in steel mill drives requiring axial shaft expansion or contraction under load, such as required to accommodate hot mill runout table roll drives, blast furnace turbine driven blower drives, and drive shafts to crane trucks where excessive

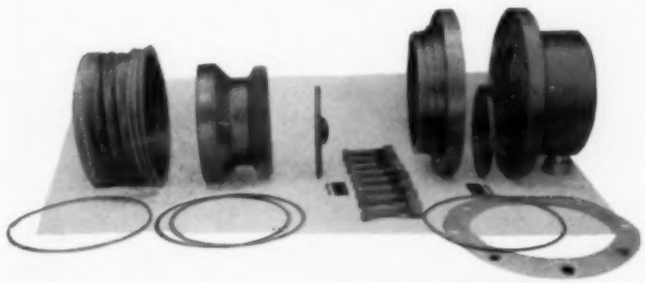


**Figure 25 — Component parts of single engagement, crane bridge track wheel half of a tandem coupling.**

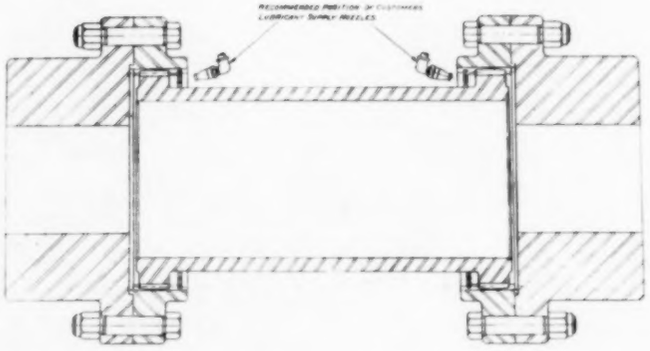
track unevenness or out of parallel is a common occurrence.

A few typical coupling applications relating specifically to steel mills follow:

Figure 25 shows a special single engagement crane bridge track wheel half of a tandem coupling which utilizes the fully-crowned tooth to accommodate plus or minus 3-degree angular misalinement. Note also the special boot seal for continuous operation at this angle. Each of these tandem coupling assemblies connects separate bridge drive motors to bridge articulated track wheels. The couplings transmit this load throughout the articulation which is caused by unusual track unevenness and gage variances.

Figure 26 shows a typical high-speed turbine driven blower coupling which operates continuously twenty-four hours per day supplying blast furnace air. Note the continuous oil lubrication system. Advantages of the

**Figure 26 — Typical high-speed turbine driven blower coupling.**



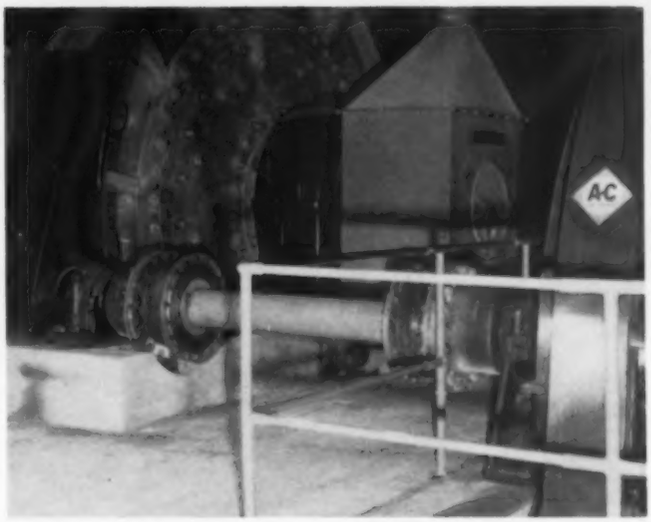



**Figure 27 — Large tandem drive fully-crowned tooth coupling transmits power to a ball mill driven by a 700-hp synchronous motor.**

fully-crowned tooth as used in this type application are obvious. Installations of this type coupling have been operating for the past five years without any maintenance. The straight-sided tooth gear type couplings which they replaced required renewal at least every one to one and one-half years. Due to high operating speeds, these couplings are dynamically balanced.

Figure 27 shows a large tandem drive fully-crowned tooth coupling as used on a raw material ball mill. These couplings operate in extremely dusty and highly contaminated atmosphere, under high torque conditions at very slow speeds. Grease lubrication has helped these couplings perform exceptionally well, particularly due to the fact that positive lubricant seals are used which prevent damaging dust particles and moisture from entering the coupling. Earlier theories of lubricating wedges to prevent gear coupling meshes from coming into metal-to-metal contact are quickly disproved in applications of this type, since there is little effect of centrifugal action forcing the lubricant between gear meshes because of low rotating speeds. The torque transmitting capacity of the fully-crowned tooth is clearly proved when subjected to this type of difficult service.

Eventually, the acceptance of the fully-crowned tooth coupling by solving the difficult problem drives, led it into the spindle roll drive field, which heretofore was recognized as one of the most difficult maintenance items in the field of rotating machinery for rolling mill equipment. As a result of the outstanding progress with fully-crowned tooth couplings on drives of this type over the past eight years, most new rolling mill equipment, requiring spindle roll drive couplings, and existing mills are converting to this coupling in place of antiquated wobbler, slipper and universal joint type drives.

Figure 28 shows installation of a single engagement tandem coupling where space allowed use of flange type construction. This is a pinch roll drive preceding a hot strip mill down coiler, and although a comparatively lighter loaded application, with the original slipper type couplings, replacement slippers were installed on an average of every two weeks. The slipper throat had to be rewelded and machined every six weeks. The original

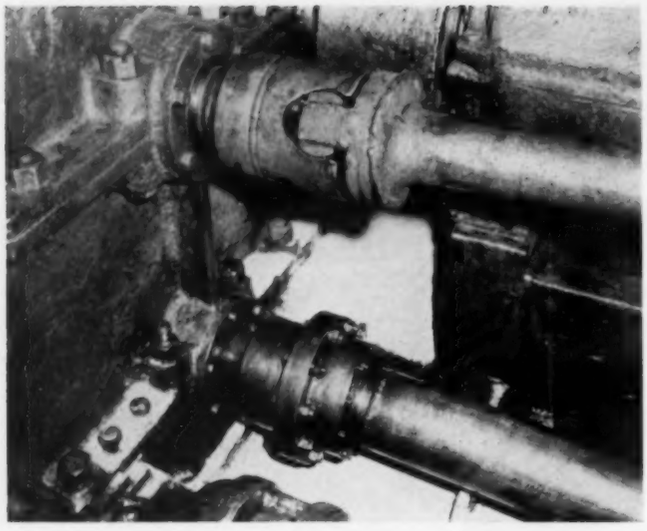


**Figure 28 — In this application, space allowed use of flange type construction.**

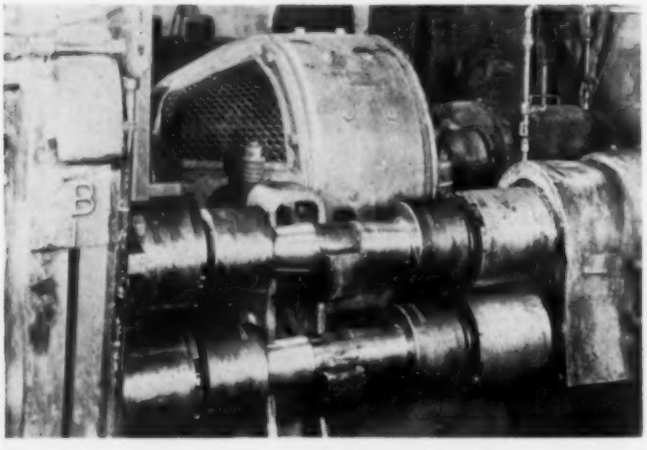


**Figure 29 — A 10-in. cold mill uses fully-crowned tooth spindle couplings with hubs machined to accommodate the original mill parts.**

crowned-tooth gear type spindle shown is still running after four years operation, and when inspected after running two years showed negligible wear and a tooth contact pattern which was ideally distributed across the center of the tooth face. The only maintenance has been an addition of grease lubricant once each year.

Figure 29 shows a modernized 2-high, 10-in. cold mill coupling that has been operating successfully for the past three years. This older style mill had cast pods on both drive and rolls. The fully-crowned tooth spindle couplings has hubs machined to accommodate the original mill parts. The only modification of these parts was on the outside diameter where they were machined to hold the hubs concentric, with the actual drive going through the original cast parts as furnished with the mill many years ago.

Figure 30 shows work roll gear type spindles in use on a 4-high 18 x 49 x 56-in. reversing cold mill that runs at a maximum of 3-degree under full load and accommodates 4-degrees during roll change. Figure 31 clearly shows the fully-crowned tooth shape and wear pattern after two years operation. Original startup of this mill subjected the fully-crowned tooth spindle couplings to many very high shocks due to strip breakage, with no tooth failure. Using standard mill greases during the initial month of operation, an unsatisfactory wear pattern was evident. With the use of proper extreme pressure greases, a good wear pattern finally resulted and many years of satisfactory service are anticipated.

Figure 32 shows the cross section of a leveler type spindle with a single engagement at each end. The fully-crowned tooth was cut to carry full load at 3-degree angular misalinement and to open to a no load of 6-degrees. Note the rising "O" ring type seal to accommodate seal scuffle, thus assuring positive lubricant retention. The sleeve can be retracted on the straight spline to accommodate quick roll change or gear drive repair.

Figure 33 shows the fully-crowned tooth spindle roll drive couplings manufactured for a 7000-fpm five-stand four-high, tandem cold mill. This is the largest fully-crowned gear type spindle built thus far, and is designed to transmit 900,000 in. lb continuous torque, accommodating 3-degree angular misalinement under no load conditions and a maximum of 1 degree angular

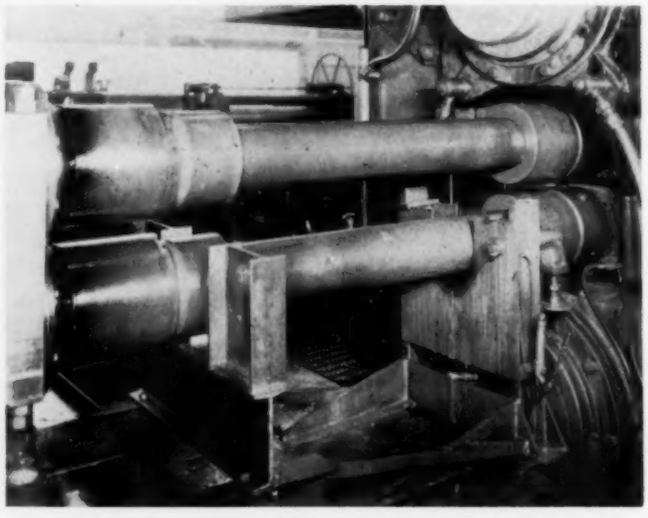
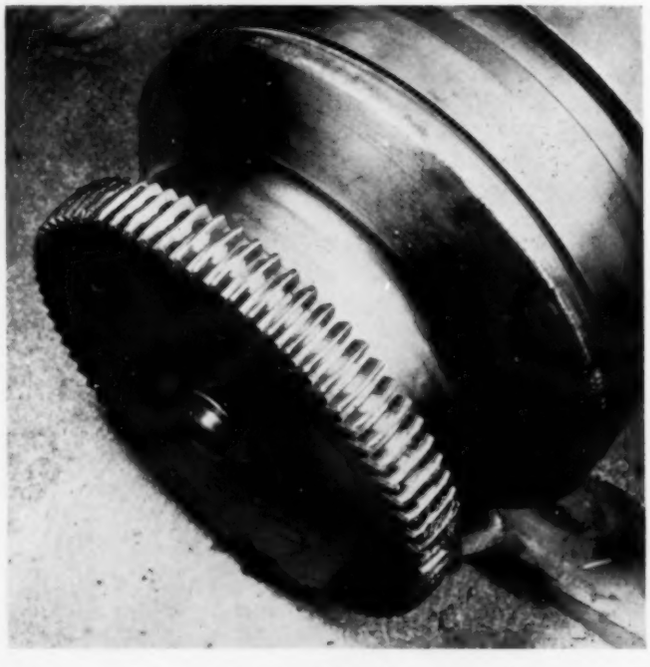


**Figure 30 — Gear type coupling is being used successfully on this 4-high reversing cold mill.**

**Figure 31 — Illustration shows wear pattern after two year's operation.**



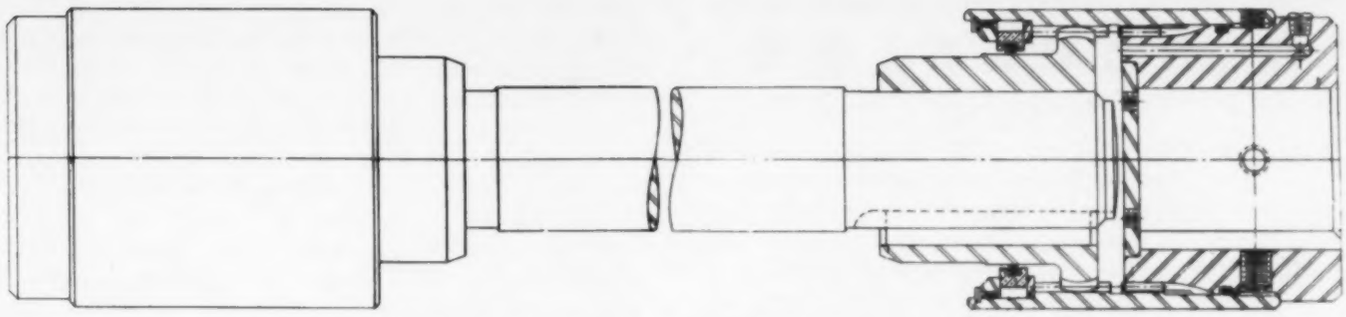


Figure 32 — Cross section through leveler type spindle.

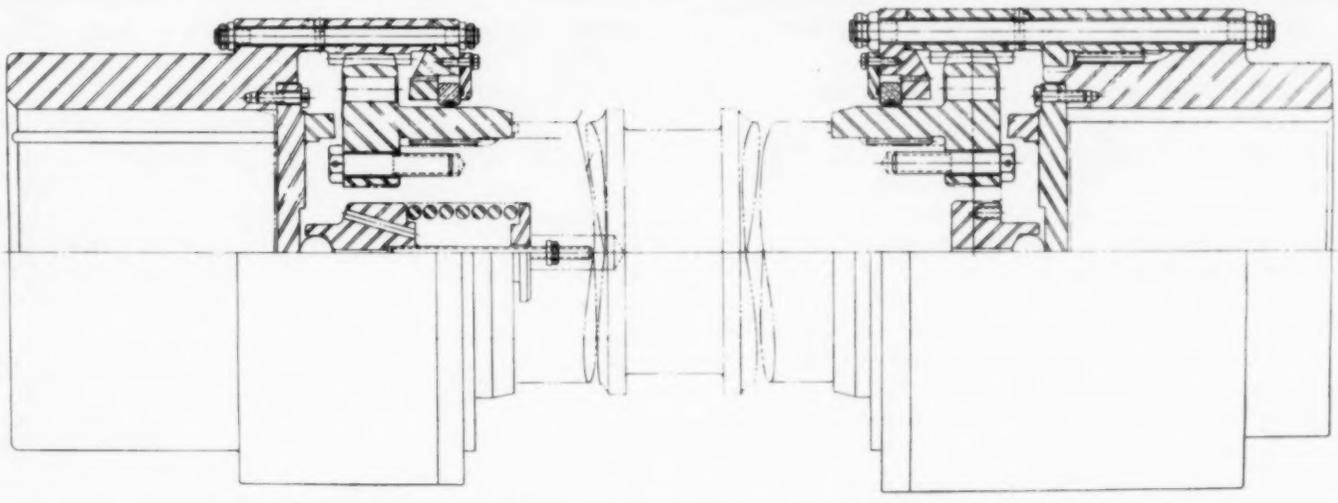


Figure 33 — Design shown is used on a 7000-fpm, five-stand, 4 high tandem cold mill.

misalinement under full load conditions. Roll change is accomplished without opening up the coupling, thereby making this a few minutes operation as compared to several hours with previous wobbler and slipper design spindle couplings. The unique design also permits replacement of the highly loaded and costlier carburized alloy steel spindle hubs and sleeves. Spindle couplings on a similar mill have been operating successfully without maintenance for over two years, well beyond expectations when installed.

It is important to point out that initial costs of fully-crowned tooth spindle roll drive couplings as compared with wobbler and slipper type couplings are almost identical. However, because of the extended life and maintenance free operation of fully-crowned tooth spindle couplings as compared with former designs, they pay for themselves in an average of one year's operation, whereas repair and maintenance costs of wobbler and slipper type couplings increases steadily from the time of the initial operation.

## SUMMARY

In conclusion, advantages of gear type couplings furnished with the fully-crowned tooth and positive lubricant hub seals may be summarized as follows:

1. Greater torque capacity for given space conditions, resulting in more efficient utilization of space and longer coupling life.

2. Wider range of misalinement capacities while still maintaining reliable torque capacity. Misalinement capacity up to 3-degree angular in standard couplings can be safely transmitted without reduction in catalog torque rating capacities, with misalinements up to 12-degree angular possible in special couplings with some reduction in torque capacity.

3. No end of tooth loading.

4. Greater freedom of axial motion.

5. Tighter fit on flanks reduces backlash, thereby reducing noise and vibration, particularly on reversing and pulsating loads.

6. Radius and relief on tips provides tighter fit resulting in positive piloting of the sleeve under all conditions, giving good dynamic balance characteristics, and reduced coupling noise.

7. Self-contained and sealed unit requiring lubricant check only at recommended intervals of three to five years for most applications.

8. Complete interchangeability half for half with ordinary straight-side tooth gear couplings, eliminating problems concerning mixed inventory.

9. More economic transmission of power due to lower initial cost, lower maintenance and replacement costs, and elimination of critical alinement and machinery construction costs.

Research and development engineers will no doubt bring forth tooth modifications in the future quite different from those described, but in any event, the obvious advantages to be gained with fully-crowned tooth couplings today make it apparent that any new gear type coupling, or any other type of coupling for that matter, will need to be outstanding in advantages, costs and performance, to surpass those already commercially available.

# DISCUSSION

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**L. J. Collins:** This paper is an excellent presentation of the many factors which should be considered in the application or design of flexible couplings. At one time, due to distress encountered, the statement was often repeated that the flexible coupling was good only to compensate for axial movement of well alined shafting and made it possible to disassemble machine elements easily.

Modern machines are more powerful and may operate at high rotational speeds. In addition, misalinement due to temperature changes is always present. Modern couplings must then operate under conditions of misalinement and the values given in Mr. Zurn's paper are realistic.

It may be impractical to apply a grease packed coupling on a particular installation due to the inability to dissipate the heat generated. Temperatures of over 1000 F have been observed on grease packed couplings operating under conditions of misalinement and rotational speeds which are perfectly normal for the apparatus involved. One solution to this type of problem is to provide a constant flow of filtered oil and to provide dams on the coupling to insure that the working surfaces are always lubricated.

The statement is made that a dammed coupling will sludge up and eventually wear out. This statement should be qualified. Records are available which contradict such a statement. Dammed couplings put in operation about 1929 are still in excellent condition. During the intervening years since 1929, these couplings have been cleaned a number of times. The foreign material removed in each instance was Fuller's earth which was packed so hard that it had to be chiseled out. The original couplings are still in excellent condition and for several years past the caked-up material has not been removed. At the time of original installation, one coupling was left undammed. This coupling was replaced and again wore out following which a dammed coupling was installed and operation since has been without incident.

If the designer of the flexible couplings is furnished with the conditions under which a piece of apparatus will operate, he can by taking into account all variables arrive at a design which will prove to be satisfactory. Where difficulty is encountered it is almost always due to some factor not being considered or perhaps it may be that it was not appreciated that the troublesome factor existed.

Mr. Zurn has presented an excellent paper and has touched upon a great many of the problems confronting coupling designers. The crowned coupling has since 1925 demonstrated its worth. On several occasions this type of coupling has been discredited but this was due to the lack of complete knowledge of the conditions under which the coupling would have to work or because of the lack of machining facilities to produce the equipment in accordance with the designs.

**H. Engvall:** Mr. Zurn's paper on "Crowned Tooth Gear Type Couplings" is more than a paper; it is practically a construction manual for gear type couplings. Because of the length and completeness of the paper, it is hard to discuss it fully and I would, therefore, rather list the basic coupling features that I believe are necessary to insure successful coupling operation. These are:

1. Correct mechanical design as far as sizes of teeth, stresses and method of mounting is concerned.

2. Accuracy of manufacture that assures as even a distribution of load as possible among all the teeth.

3. Male teeth should be crown-shaved to avoid end loadings of the teeth and to assure correct tooth form and proper tooth finish.

4. Female teeth should be straight-shaved. This assures maximum tooth spacing accuracy, proper tooth form and satisfactory tooth finish.

5. Proper lubrication. This can be accomplished in various ways. If continuous lubrication is used it is very important that sufficient lubricant is supplied.

6. The material used in both the male and female coupling should be of sufficient hardness to transmit the required load without undue wear taking place.

It appears that all of these requirements have been included in Mr. Zurn's recommendations. Many of the claims made by Mr. Zurn for the crowned coupling are perhaps correct, particularly in the low speed field, but the effect on load carrying capacity due to misalinement should not be overlooked. As far as high-speed machinery is concerned, we should look upon flexible couplings as being just that, and not universal joints, and that proper alinement is extremely important for successful operation.

Mr. Zurn deserves a great deal of credit for having presented a very instructive and complete analysis of past and present gear type coupling designs.

**G. E. Farrington:** Mr. Zurn touched lightly upon the limits of misalinement when using gear type couplings. About seven years ago, we felt a gear type coupling could either be modified or redesigned to transmit large torque values at a relatively high degree of misalinement, such as occurs on mill spindles, roller levellers, pinch roll units and equipment of similar nature, where the degree of misalinement was not constant from one time or condition to another.

To try out our idea we chose a tandem temper mill which had been in successful operation for several years and which had only one work roll per stand connected to the drive. This mill used 19-in. diameter work rolls and had a top speed of 1800 fpm.

A spindle coupling was developed to handle maximum torque at a maximum angularity of 3-degrees at base speed of the motor. The drive and roll end couplings were duplicated as far as gear design was involved and a crowned tooth was used on the male or spindle half of the coupling while a straight gear tooth was used on the internal ring gear or drive and roll end coupling half. Proper provision was provided for end thrust by the use of hardened semispherical buttons in the male portion, and hardened wear plates in the bottom of the section having internal teeth.

The sealing of grease or lubricant in the coupling and exclusion of foreign dust and material from the coupling presented somewhat of a problem, but it was solved fairly successfully by the use of a lip type seal between the two coupling halves.

Provision was also made to prevent disengagement of the male and female portions by the use of retaining rings bolted to the internal gear unit which interfered with the external teeth when the roll neck was pulled out of the coupling during roll changing operations. With the roll in place, ample clearance was maintained between the external teeth and the retaining ring because of the work rolls fixed end position in the mill housing. Approximately 0.062 in. of clearance was kept at each end between buttons and thrust plate which permitted the spindle shaft to float a total of $\frac{1}{8}$ in. from maximum clearance at one end to zero clearance at the other.

This spindle was installed in August and used continuously until about January. Maintenance records indicated that no trouble was experienced, and since slippers, center blocks and spindle support bearings were eliminated, the savings in operational and maintenance costs indicated this spindle would completely amortize its cost in seven months.

However, the user of this first four high mill crowned tooth gear spindle desired considerable clearance between the roll end coupling bore and the roll neck or wobbler. At one visit made by the speaker, it was found that $\frac{1}{4}$-in. clearance was being used. This obviously imposed a tremendous overloading and tendency for wear on the gear teeth. Inspection of the teeth, however, showed only minimum wear and most of this was attributed to the failure of the lip seal due to excessive misalinement.

This spindle was installed on an experimental basis, and from its operation were determined several faults in design and construction which have long ago been corrected.

The sealing problem was eliminated by the use of boots made from neoprene impregnated duct wound upon a spiral spring. On the drive end coupling which does not require changing or separation, the boot was secured at both ends by clamp rings similar to an air hose clamp. This then attained a self enclosed and sealed reservoir for grease and prevented contamination from outside sources.

On the roll end coupling we felt that the coupling should be disengaged when changing rolls, with the roll end half remaining on the roll neck in a manner similar to the old style spade of a slipper coupling. The boot as used on the drive end therefore was not practical on the roll end since each change of rolls would require removal of the clamp and replacement when new rolls were placed in the housings. We therefore developed a boot which was held on the spindle end by a circumferential clamp with the roll end fitting into a V groove machined into the end of the roll end half coupling. Since the boot was compressed, sufficient tightness was obtained to prevent lubrication from escaping at high rotation.

We have used this design extensively in the past six years and with very satisfactory results. For instance on one mill stand which has operated as high as 7200 fpm, leakage is negligible.

This design also permits a close fit between roll neck and half coupling, thereby eliminating eccentricity of the spindle and the resulting vibration and excessive wear which so frequently occurs on spindles of the slipper type. Please note that no end thrust is required to seat the spindle and couplings as is needed on a slipper type. This therefore reduces thrust wear on drive bearings or thrust stand bearings as well as on work roll bearings.

For the past four years we have used the crowned tooth flexible coupling principle on all spindles used on equipment supplied by us and have manufactured these couplings in our plant for the past twelve months, not only for our products, but also for other mill and machinery builders.

In a previous paper at this convention, there was considerable discussion in regard to slippers on blooming mills. We are, at the present time, installing a roughing slabbing mill where we are using crowned tooth couplings in place of slippers. It is still too early to give any results on this installation, but we hope that we will eliminate many lubrication and maintenance problems by the use of the crowned tooth coupling.

**Walter E. Matthews:** My comments pertain to gear type couplings in general for use on steel plant rolling mills, however, I am in full agreement with the principle of spherical or curved tooth couplings. They are certainly a great improvement over the old conventional type couplings, particularly for high-speed mills. However, it should be remembered that when such couplings are used on rolling mills as a connecting link between the drive and the rolls, that they must be carefully designed, perhaps overdesigned, to provide the needed structural strength to withstand the abuse to which they may be subjected.

In most cases, couplings of this type are manufactured using conventional type gear cutting tools which produce an involute gear tooth form. I do not believe that it is necessary to have the conventional gear tooth form since there is no rolling action between the members of the coupling. I feel that a 30-degree pressure angle spline type tooth of larger dimensions would be better. This would give greater beam strength. It is true that as the teeth are made larger or the operating angularity increased, more clearance has to be allowed, but I feel this is a lesser evil than keeping the teeth small in size. The materials used are also important

and careful thought should be given to selecting the right alloys with proper heat treatment cycles to give maximum wear as well as maximum beam strength to withstand high shock and load conditions.

Our experience with gear type couplings is that the conventional type tooth of ordinary materials, even with the best lubrication possible under operating conditions, wears out or breaks too quickly.

I want to take this opportunity to compliment the author on a fine paper and hope that through the combined and co-operative efforts of the designer, manufacturer and consumer, that better couplings for rolling mills, so important to the steel industry today, will result.

**B. J. Oberembt:** In the beginning of Mr. Zurn's paper he made some comments about the way in which other types of flexible couplings accommodated misalinement. I would like to correct one impression that he left, that while it was true that most of these other couplings accommodate misalinement by deformation of the connecting elements, this is not true in the steel grid coupling. He mentioned that it was the function of the grid member in steel grid coupling to take care of misalinement. This is incorrect. Actually the steel grid coupling accommodates misalinement in the same fashion as the sleeve and hubs functioning together on a gear type coupling, that is the hubs rock and slide on the grid member. There is no bending of the grid member as was intimated.

**Frank W. Zurn:** Referring to Mr. Oberembt's comments regarding method of accommodating misalinement in the steel grid type coupling, currently available technical literature does not agree entirely with the views expressed here, as evidenced by the following quote:

"Under normal load the members of the grid springs are only slightly *bent*. Thus the maximum distance between spring member contact points ensures a very flexible connection between the driving and driven coupling discs. Under increasing load, the grid springs are markedly deflected (bent) and distance between grid spring contact points decreases accordingly. . . ."

Based on the above information relating to normal load conditions, bending of the steel grid is exaggerated even further when parallel or angular misalinement is introduced into the connected system. The continual cyclic flexing of the grid member introduces reactionary bending stresses which are transmitted onto the connected equipment bearings. At the same time the power absorbed in the steel grid during bending may cause it to break due to metal fatiguing.

**J. H. Hitchcock:** It is extremely gratifying to observe recognition on the part of the commercial coupling manufacturers of the merits of this type of coupling. Our company first applied this principle to rolling mill coupling spindles in 1938, and since 1942 we have applied the principle very extensively in the rolling mills which we manufacture. We agree fully with Mr. Zurn's statements regarding the advantages of this type of coupling. Extensive experience during the last fifteen years has demonstrated that the crowned tooth form, in combination with adequate lubrication and proper selection of materials and heat treatment, provides excellent durability and minimum maintenance on rolling mill coupling spindles.

In contrast to numerous industrial coupling applications where considerations of space, torque and misalinement permit compromise in the interest of economy, rolling mill spindles require couplings which will transmit high torque at misalinement up to or exceeding 3-degrees, and which can be installed and removed readily within the space limitations prescribed by the diameter of rolls and mill pinions. Gear type couplings with crowned tooth form, made from hardened steel, are admirable for this purpose.

Various methods are available for producing the crowned tooth form, and selection among these methods can be based solely on considerations of convenience and economy. In our shop the crowned tooth form is produced by hobbing in a patented modification of an early hobbing machine. This is convenient, economical and entirely satisfactory.

For many years both internal and external elements of these gear type couplings have been made from low carbon steel of carburizing grade, with case carburizing and hardening following machining of the teeth. Quenching fixtures are employed with the elements containing internal teeth to minimize distortion. More recently some couplings have been made by nitriding, and although field experience with couplings heat treated by this process is still limited, it appears that performance will be entirely satisfactory.

It is interesting to note that many couplings of this type we built as long ago as 1942 are still in use, despite virtually continuous service throughout this period.

# CURRENT AISE DISTRICT SECTION MEETING NOTICES

## BIRMINGHAM SECTION

Friday, Sept. 13, 1957

Dinner 6:30 P.M.

Meeting 8 P.M.

**Golden (50th) Anniversity Meeting,** William E. Hamilton, Master of Ceremonies; J. D. O'Roark, President AISE, 1957, speaker; and Dr. Alfred P. Haake, author, lecturer, and consultant to General Motors Corp., guest speaker.

Birmingham Country Club

## ST. LOUIS SECTION

Wednesday, Sept. 18, 1957

Social Hour 6 P.M., Dinner 7 P.M.

Meeting 8 P.M.

**"Application of Industrial and Crane Brakes,"** Wagner Electric Corp., St. Louis, Mo.

Elks Club

Granite City, Ill.

Figure 1 — Geneva plant was purchased from the government in 1946.

# The Facility Round-Out Program at Columbia-Geneva

By HAROLD G. DEGITZ

Staff Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

*. . . . in the last ten years, this division of United States Steel Corp. has increased its annual rated ingot producing capacity by about 1,000,000 tons . . . . increase has been accomplished through improvements and balancing facilities . . . . a number of unique expedients were adopted to avoid downtime during the construction work . . . .*

▲ COLUMBIA-GENEVA Division of United States Steel Corp. is in the final phase of a program started two years ago to increase the steel making and finishing capacity of its Geneva Works near Provo, Utah, and the Pittsburg Works in California. When the expansion is completed, it will increase the steel making capacity at Geneva by about 20 per cent and give a substantial increase to the finishing capacity at Pittsburg. This program is the latest among many that have been carried out during the 27 years in which United States Steel has been operating steelmaking facilities in the West.

The early history of steelmaking in the Western States, has been covered in previous papers. Therefore, in this discussion we will start with 1946 which was the year United States Steel acquired the facilities in Utah that had been built by the Defense Plant Corp. to further the war effort. These facilities included the Geneva Works and Keigley Quarry near Provo, the Geneva Coal Mine near Price, and certain iron-mining facilities at Iron Mountain near Cedar City. In addition to these facilities which were acquired from the War Assets Administration, United States Steel was already operating a blast furnace at Ironton, Utah, which was

now to become part of the over-all steel-producing facilities in this area.

Geneva Works (Figure 1) as purchased from the Government included 252 by-product coke ovens, three 1120-ton blast furnaces, nine 225-ton open hearths, a 45-in. high lift slab and blooming mill, a 4-stand 132-in. semi-continuous plate mill, a structural mill and the necessary auxiliary facilities to maintain the plant in full production at a rated capacity of 1,283,400 net tons of ingots per year. Geneva had been designed and built for the production of plates and structural shapes needed for the war time ship building program.

In 1946, United States Steel started a program to convert its Utah properties into an operation capable of serving the peace time economy in the West. The first step was to convert the 132-in. plate mill to a facility that could produce hot rolled strip in coil form. Basically this was accomplished by adding two finishing stands and coilers to the existing four-stand plate mill and providing the additional buildings and handling equipment required. During the next four years, improvements and additions continued at Geneva to such an extent that by 1950, the annual rated ingot capacity was 1,400,000 tons, an average increase of more than 100,000 tons per year. In 1950, the program was continued with the installation of hot rolled sheet shear line and the tenth open hearth furnace. At the ore mine a new crushing and loading plant was built and other improvements were made in the area to provide an adequate supply of iron ore for the new steel-producing developments. This newest addition brought the rated capacity to 1,600,000 ingot tons per year by 1952, an increase of 200,000 tons. The geographical relation of the various Utah operations and the Pittsburg Works at Pittsburg, Calif., are shown in Figure 2.

During this same conversion and development period in Utah, there was also an extensive program at Pittsburg Works where new flat rolled finishing facilities were being installed to process the hot rolled coils provided from Utah. The new equipment included a 5-stand cold reduction mill, a pickling line, an electrolytic cleaning line, temper mills, a sheet galvanizing line, hot dip tin lines and an electrolytic tinning line, together with related appurtenances required to finish and ship the flat rolled products from these facilities. Figure 3 shows Pittsburg Works prior to this program and Figure 4 is a view while the work was under way. From 1950 to 1953, a second major program was undertaken at Pittsburg. This included such major items as a 4-stand cold mill, a second continuous pickling line, additional annealing furnaces, a side trim and recoil line, a continuous galvanizing line, and a second high speed electrolytic tinning line. In addition, numerous items such as special processing and handling facilities, cranes, buildings, etc., were provided. The building extensions and additions to the sheet and tin mill amounted to about 12½ acres of floor space. This added to the existing buildings, brought the plant total at Pittsburg Works to about 37 acres under roof. Figure 5 shows the plant after the program was completed. The new facilities at Pittsburg started operations early in 1953.

In 1955, the latest program of Columbia-Geneva Division was begun after studies showed that by using the combined capacity of the coke plant and the blast

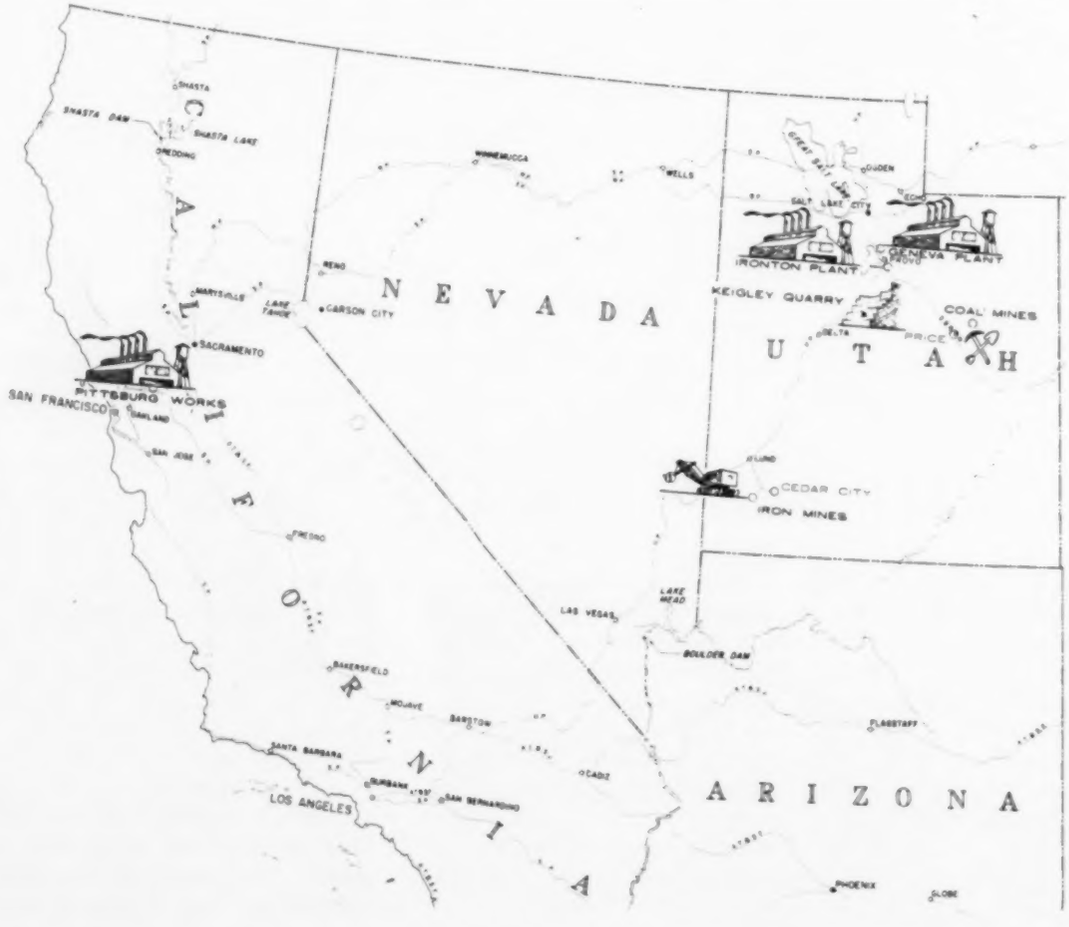


**Figure 2 — Facilities of the Columbia - Geneva Steel division are scattered over a wide area.**

**Figure 3 — Aerial view of Pittsburg Works prior to improvement program.**

**Figure 4 — Construction is now under way.**

furnaces at Geneva and Ironton, sufficient hot metal could be obtained to supply the increased requirements. The studies showed, however, that production at the higher rates would require continuous operation of the two blast furnaces at Ironton and transportation of the hot metal from the Ironton Plant to the Geneva open hearth furnaces.

The major changes, however, were required at the Geneva open hearth department, where a bottleneck in operations appeared certain. When the latest program was undertaken, this department had seven furnaces with a hearth area of 936 sq ft and a rated heat size of 225 tons each, one furnace with 975 sq ft rated at 235 tons, one furnace with 1062 sq ft rated at 240 tons, and one furnace with 1173 sq ft rated at 260 tons. The plan was to rebuild and modify all furnaces to tap 300-ton heats. When the tenth furnace was installed in this shop in 1952, a new and improved furnace design was developed by Columbia-Geneva engineers. This design employs a single span, rigid arch frame as shown in Figure 6. Notice that the working area beneath the center of the pan is much larger than with a conventional furnace and it is unobstructed. The construction has many advantages. It eliminates some difficult maintenance problems and also facilitates certain operations. The installation of this type of construction is shown in Figure 7. The major advantage of the single span, rigid arch frame in the Geneva round-out program was the nature of the design. The plans called for rebuilding nine of the ten furnaces. This indicated a probable large loss in production during the rebuilding period if conventional methods were used, a loss that was avoided by the construction method developed by the engineers at Geneva Works. All of the frame work for the furnaces was erected outside the shop and then moved to permanent locations in the assembled condition. Figure 8 shows a completed frame being moved into the shop. This experiment has shown that the rigid arch design is most suitable for this type of erection. Through the use of this method, loss of valuable producing time representing many days on each furnace was avoided. The procedure was used on all of the furnaces which were rebuilt. In the case of the last furnace to be rebuilt, however, an additional unique and highly successful experiment was accomplished. The entire furnace was rebuilt outside of the shop, including the placement of 33 carloads of refractory brick, before being moved 900 ft into position. Total transit time for the move-in was 78 min.

Downtime on this furnace was only 11 days, compared with customary periods running as high as 30 days out of production for furnace rebuilds in the conventional manner. The downtime on the previous rebuilds using the prefabrication method, but laying the brick after the furnace was moved into position was approximately 16 days.

To make the move into the shop as simple as possible, the furnace was constructed on six ingot mold cars mounted on three sets of tracks. On previous move-ins, only four cars and two sets of tracks were required. The additional weight of the refractory lining made it necessary to add the third set of cars and track for the last furnace.

An erection platform of specially designed beams was installed on the six cars. Roller assemblies were then installed on the top of the beams so the furnace could be rolled into place when it reached its shop location. Rigid frame base plates were mounted on the rollers and the furnace was constructed as on the other prefabricated rebuilds.

With brickwork to be installed on the furnace ends, steel girders and attaching members were designed to provide support for the cantilever load and thus eliminate any deflection in the structure of the furnace. Tie rod bracings across the ends of the furnace roof, on the vertical face of the furnace, and vertically on the furnace sides were also installed to prevent any movement or sway in these areas during the transfer.

The three sets of tracks were extended from the erection site 900 ft in the open hearth pit to the furnace location. About three feet of dolomite fill were placed under the tracks to insure uniform bearing surface for the track ties. A heavily reinforced concrete pad, approximately four feet thick, was previously poured in the pit at the cross transfer location.

**Figure 5 — View shows plant, Pittsburg Works, after completion of program.**

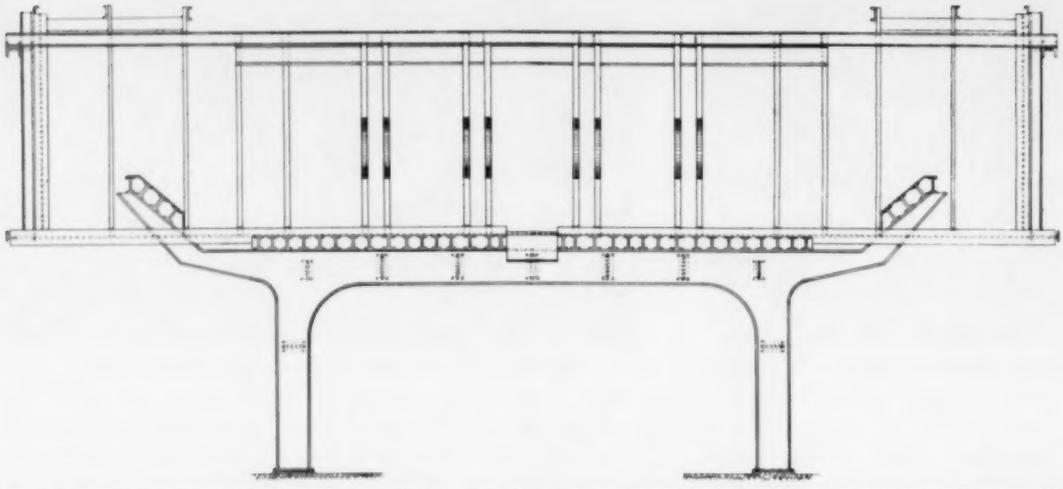

**Figure 6 — New furnace design uses a single span, rigid arch frame.**

This was the site where the furnace would be transferred from the cars to the foundation columns which support it during operation. Two structural steel transfer bridges were fabricated to carry the furnace across the space between the erection platform on the cars and the foundation columns. These bridges consisted of two sets of heavy structural steel pedestals, beams and plates on top, smooth enough for the rollers which carried the furnace into place.

When the rebuilt furnace was ready for the move-in and the old furnace had been dismantled and removed, a job that took six days, one of the plant's 120-ton diesel switch engines was coupled to the middle mold car bearing the furnace. The hangover on the end of the furnace structure made a train of two handle cars necessary. The couplers of the locomotive, the handle cars, and the ingot mold cars were blocked in extended position to eliminate any possible slack resulting from the locomotive changing from a pushing to a braking action.

The moving operation was held to an extremely low speed through the use of a special rheostat push button control. The furnace was accurately alined and the transfer bridge assemblies positioned in perfect alinement with roller plates on the foundation columns on one side, and the furnace rollers on the other. Upon arrival at the cross transfer section and after the furnace was alined, the locomotive and handle cars were uncoupled and removed from the pit area.

A double drum hoisting engine driving through a torque converter had been installed and the cable from each drum reeved to provide a 12-part line to pull the structure on the rollers. Another 4-part line was used as a hold back for braking. In approximately 20 min, the structure had been moved to position on the supporting columns and the final position of the furnace was made. The final phase of the rebuild consisted of making the tie-ins between the furnace and existing facilities (piping, structural and electrical) and sealing the slag pockets and checker chambers. With the job completed, the furnace fuel was turned on just 11 days after tapping the last heat from the old furnace.

The major change made in all of the furnaces during the Geneva Works rebuilding was enlargement of the hearth area of each to 1146 sq ft, to increase their capacity to 300-ton heats. To handle the larger heats, it was necessary to acquire bigger ladles, increase the capacity of the three existing pit cranes to 450 tons and provide added crane facilities. Further, to secure the increased production in the open hearth department, it was necessary to rearrange open hearth yard tracks to permit more rapid flow of material to the furnaces. Additional material-handling units including charging box cars, charging boxes, ingot mold cars and a hot metal transfer car and ladle were also required for operations at the higher level.

Part of the additional production will be in the form of hot rolled coils which will be shipped to the Pittsburg Works at Pittsburg, Calif. for further processing and finishing. The one major item required was a new line for the production of additional ferrostan electrolytically-coated tin plate.

The facility round-out program at Columbia-Geneva will increase the annual basic producing capacity of this division of United States Steel to about one million tons more than the capacity which existed just ten years ago.

**Figure 7 — New arch frame design aided reconstruction.**

**Figure 8 — Framework of furnace was erected outside of shop and moved into place after assembly.**

# Association of Iron and Steel Engineers
# 1957 Annual Convention

## 50TH ANNIVERSARY

HOTEL PENN-SHERATON PITTSBURGH, PA.

SEPTEMBER 23, 24, 25, 26

# PROGRAM

# Association of Iron and Steel Engineers

# 1957 Annual Convention

## HOTEL PENN-SHERATON PITTSBURGH, PA.

## SEPTEMBER 23, 24, 25, 26

### MONDAY, SEPTEMBER 23

**9:00 am—REGISTRATION—**
**Fort Duquesne Room**

**9:15 am—BUSINESS MEETING—**
**Urban Room**

Conducted by President J. D. O'Roark

**9:30 am—ELECTRICAL SESSION—**
**Urban Room**

Chairmen: John F. Kostelac, Assistant Electrical Superintendent, Crucible Steel Company of America, Midland, Pa.

E. L. Anderson, Superintendent Electrical Dept., Bethlehem Steel Co., Johnstown, Pa.

**"Standardized Component Parts for Heavy Duty Mill Type Cranes,"** by Myron R. Bowerman, Director of Research, and Elvin R. Madison, Research Engineer, The Alliance Machine Co., Alliance, Ohio

**"Increasing Open Hearth Capacity by Use of Light Weight Ladle Trolleys,"** by F. C. Schoen, Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

**"An Automatic Gage Control System for Tandem Cold Mills,"** by N. S. Walker, General Maintenance Foreman, Tin Mill Cold Reduction Dept., Gary Sheet and Tin Mills, United States Steel Corp., Gary, Ind., J. W. Cook, Steel Mill Engineers, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa., and J. W. Wallace, Mill Systems Development Engineer, Control Engineering Dept., Westinghouse Electric Corp., Buffalo, N. Y.

**9:30 am—COMBUSTION SESSION—**
**Monongahela Room**

Chairmen: F. B. Bevelheimer, Power and Fuel Engineer, Engineering Dept., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

F. C. McGough, Superintendent, Maintenance and Construction, Detroit Steel Corp., Portsmouth, Ohio

**"Open Hearth Fuel Atomization with Reaction Type Jet Burners,"** by G. W. Hinds, Development Engineer (Metallurgy), and A. L. Hodge, Staff Engineer (Metallurgy), Development Laboratory, Linde Co., Div. of Union Carbide Corp., Newark, N. J.

**"Accelerated Firing Rates in Open Hearth Furnaces,"** by E. T. W. Bailey, Chief Combustion Engineer, The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

**2:00 pm—MECHANICAL SESSION—**
**Monongahela Room**

Chairmen: R. A. Kraus, Assistant Superintendent of Maintenance, Republic Steel Corp., Chicago, Ill.

E. F. Donatic, General Superintendent, Kaiser Steel Corp., Fontana, Calif.

**"Magnetic-Flux Gas-Shielded Arc Welding,"** by J. E. Dato, Manager Eastern Region—Electric Welding, Linde Co., Div. of Union Carbide Corp., New York, N. Y.

**"Railroad Car Rebuilds and Repair at Kaiser's Fontana Works,"** by A. B. Stoker, Foreman, Car Repair Shop, Kaiser Steel Corp., Fontana, Calif.

**"Planned Maintenance Techniques for A Hot Strip Mill,"** by James R. Kennedy, Maintenance Foreman, Hot Mill Mechanical Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

**2:00 pm—OPERATING PRACTICE SESSION—**
**Urban Room**

Chairmen: G. I. Bottcher, Chief Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

S. O. Evans, Manager, Tubing Operations, Tubular Products Div., Babcock & Wilcox Co., Beaver Falls, Pa.

**"The Replacement of Steel Mill Plant and Equipment with Present Depreciation Reserves,"** by William T. Hogan, S.J., Professor of Economics and Director, Economics Program, Fordham University, New York, N. Y.

**"Design of a Large Tonnage Continuous Casting Plant,"** by Rufus Easton, Manager Continuous Casting Section, Freyn Dept., Koppers Co., Inc., Pittsburgh, Pa., and Harold E. Skelley, Power and Fuel Engineer, Engineering Dept., Inland Steel Co., Indiana Harbor Works, East Chicago, Ind.

**"The Dollars and Sense of Pickle Liquor Treatment,"** by James S., Joseph, Sales Engineer, and Elbert T. Culver, Senior Process Engineer, Chemical Dept., Engineering and Construction Div., Koppers Co., Inc., Pittsburgh, Pa.

### TUESDAY, SEPTEMBER 24

**9:00 am—ELECTRICAL SESSION—**
**Urban Room**

Chairmen: D. C. McCrady, Superintendent, Electrical Dept., Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

J. A. Drgon, Division Superintendent, Maintenance and Utilities, Edgar Thomson Works, United States Steel Corp., Braddock, Pa.

**"Electrical Advances Can Reduce Installed Cost,"** by E. E. Vonada, Product and Application Specialist, Reliance Electric and Engineering Co., Cleveland, Ohio

**"Protection Against Prolonged Delays on Main Drive Electrical Equipment,"** by H. H. Angel, Electrical Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

**"Selection of Electric Equipment for Temper and Skin-Pass Mills,"** by J. E. Peebles, J. J. Remley, and R. B. Eggleston, Steel Mill Engineers, Systems Application Engineering Section, General Electric Co., Schenectady, N. Y.

### 9:00 am—COMBUSTION SESSION—
### Monongahela Room

Chairmen: R. A. Lambert, Superintendent, Steam Efficiency and Combustion Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

W. M. Bloom, Fuel Engineer Allegheny Ludlum Steel Corp., Brackenridge, Pa.

**"High Velocity Gas Stress Relieving Furnace,"** by Edward M. Yard, Chief Project Engineer, Mechanical, John A. Roebling's Sons Corp., Trenton, N. J.

**Fast Annealing of Sheet-Strip Coils with Helium Injection,"** by J. D. Keller, Partner, Associated Engineers, Pittsburgh, Pa.

**"Continuous Annealing 60 Tons per Hour of Tinplate,"** by J. Neil Laidman, Engineer, Physical Metallurgy Section, Research Dept., Bethlehem Steel Co., Sparrows Point, Md., and Quentin M. Bloom, Manager, Furnace and Kiln Div., Selas Corp. of America, Dresher, Pa.

### 2:00 pm—OPERATING PRACTICE SESSION—
### Urban Room

Chairmen: W. O. Bishop, Superintendent Blast Furnaces, Inland Steel Co., East Chicago, Ind.

John M. Walsh, Assistant General Superintendent, Gary Steel Works, United States Steel Corp., Gary, Ind.

**"Modern Methods of Iron Ore Reduction,"** by H. W. McQuaid, Consulting Metallurgical Engineer, Cleveland, Ohio

**"Techniques in Rebuilding a Blast Furnace,"** by C. F. Bessent, Supervisor, Mechanical Maintenance Dept., Bethlehem Steel Co., Sparrows Point, Md.

**"Distributing Raw Materials in Blast Furnaces,"** by Henry W. Campbell, Chief Engineer, Interlake Iron Corp., Cleveland, Ohio

### 2:00 pm—LUBRICATION SESSION—
### Monongahela Room

Chairmen: C. A. Bailey, Lubrication Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

C. T. Lewis, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio

**"The Importance of Pumpability and Heat Stability in Industrial Greases,"** by Wm. A. Magie, 2nd, Vice President, Magie Bros. Oil Co., Franklin Park, Ill.

**"Important Considerations in the Design of Modern Centralized Lubricating Systems,"** by G. C. Almasi, Materials and Standards Engineering Div., Crucible Steel Company of America, Midland, Pa.

**"Development and Application of Spray Lubrication,"** by E. J. Gesdorf, Senior Application Engineer, The Farval Corp., Cleveland, Ohio

### 6:00 pm—OLD TIMERS DINNER—
### Urban Room

## WEDNESDAY, SEPTEMBER 25

### 9:00 am—ROLLING MILL SESSION—
### Urban Room

Chairmen: A. M. Cameron, Superintendent, Blooming and Bar Mills, Atlas Steels, Ltd., Welland, Ontario, Canada

R. C. Schaefer, Superintendent Hot Strip Mill, Wheeling Steel Corp., Steubenville, Ohio

**"Automatic Contour Turning of Large Mill Rolls,"** by William Hyams, Manager of Machinery Sales, Mackintosh-Hemphill Div., E. W. Bliss Co., Pittsburgh, Pa.

**"Some Practical Solutions to Hot Mill Problems,"** by R. A. Smith, Assistant General Foreman, and A. D. Patton, Assistant to General Foreman, 96-In. Hot Mill, Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

**"Application of Stretch Reducing of Tubes—For Greater Production and Economy,"** by William Rodder, First Vice President, The Aetna-Standard Engineering Co., Pittsburgh, Pa.

### 9:00 am—LUBRICATION SESSION—
### Monongahela Room

Chairmen: A. E. Cichelli, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

D. E. Whitehead, Materials and Standards Engineer, Crucible Steel Company of America, Pittsburgh, Pa.

**"Large Motor Bearings,"** by Walter T. Saveland, Jr., Supervisory Engineer, Renewal Parts and Service, Motor and Generator Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

**"Maintenance of Oil Film Bearings on European Mills,"** by Samuel Carson, Field Engineer, Morgan Construction Co., Worcester, Mass.

**"Ten Painting 'Reminders' for Steel Plants,"** by Walter T. Yarhouse, Industrial Sales Representative, The Sherwin-Williams Co., Cleveland, Ohio

### 2:00 pm—OPERATING PRACTICE SESSION—
### Urban Room

Chairmen: R. W. Holman, Director of Control Mechanisms Research, Research and Technology Div., United States Steel Corp., Pittsburgh, Pa.

Emil Kern, Vice President in Charge of Engineering, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

**"Steel Industry in Mexico—Its Present and Immediate Future,"** by Pascual Gutierrez Roldan, Managing Director, Altos Hornos de Mexico, S. A., Mexico, D. F.

**"The Steel Industry in India—Yesterday, Today and Tomorrow,"** by E. T. Warren, President, Tata, Inc., New York, N. Y.

**"European Steelmaking Today—The Technical and Economic Picture,"** by Alastair McLeod, Editorial Director-Technical, Industrial Newspapers, Ltd., Adelphi, London, England

### 2:00 pm—ELECTRICAL SESSION—
### Monongahela Room

Chairmen: R. G. Nolan, Electrical Engineer, Granite City Steel Co. Granite, City, Ill.

R. T. Winterringer, Assistant Superintendent, Electrical Dept., Republic Steel Corp., Chicago, Ill.

**"Light Flicker Caused by Electric Steel Furnaces,"** by W. E. Schwabe, Product and Process Development Laboratories, National Carbon Co., Div. of Union Carbide Corp., Niagara Falls, N. Y.

**"Trends in Ingot Buggy Design,"** by H. G. Frostick, General Supervisor Design Engineering (New Mills Construction), South Works, United States Steel Corp., Chicago, Ill.

**"Blast Furnace Automatic Charging Control System,"** by S. P. Curtis, Chief Engineer, Fairless Works, United States Steel Corp., Fairless Hills, Pa., R. F. Schramm, Chief Electrical Engineer, Arthur G. McKee & Co., Cleveland, Ohio, and D. W. Fath, Senior Engineer, Cutler-Hammer, Inc., Milwaukee, Wis.

### 7:00 pm—FORMAL DINNER—Ball Room

Speaker: George Jason

### 10:00 pm—DANCE—Urban Room

AISE members and guests. No admission charge.

## THURSDAY, SEPTEMBER 26

### 9:00 am—COMBUSTION SESSION—
### Urban Room

Chairmen: G. H. Krapf, Division Superintendent, Power Production, South Works, United States Steel Corp., Chicago, Ill.

F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

**"Trends in Steel Mill Power Plants,"** by Howard G. Kitt, Senior Power Engineer, and Robert W. Worley, Chief Power Engineer, United Engineers & Constructors, Inc., Philadelphia, Pa.

**"Gas Storage for Peak Demands,"** by Robert Kyle, Vice President, The Gas Machinery Co., Cleveland, Ohio

**"New Combustion Process for Temperature Uniformity in Heat Treating Furnaces,"** by F. C. T. Daniels, Consultant, and Steve Stasko, Assistant Chief Metallurgist, Mackintosh-Hemphill Div., E. W. Bliss Co., Pittsburgh, Pa.

### 9:00 am—MECHANICAL SESSION—
### Monongahela Room

Chairmen: H. R. Knust, Assistant General Manager, Bethlehem Steel Co., Sparrows Point, Md.

L. A. Fugassi, Assistant Chief Engineer, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.

**"Safeguarding Steel Production,"** by R. M. L. Russell, Assistant Chief Engineer, Factory Insurance Association, Hartford, Conn.

**"Some Heavy Industrial Noise Problems, Their Analyses and Solutions,"** by Richard D. Lemmerman, Manager, and Richard R. Audette, Assistant Chief Engineer, Industrial Sound Control Dept., Koppers Co., Inc., Baltimore, Md.

**"Treatment of Liquid Water-Borne Wastes from Steel Plants,"** by Ross Nebolsine, President, Hydrotechnic Corp., New York, N. Y.

### 2:00 pm—OXYGEN SESSION—
### Urban Room

Chairman: J. H. Strassburger, Assistant Vice President, National Steel Corp., Pittsburgh, Pa.

**"Summary of Operating Results with Oxygen,"** by J. H. Strassburger, Assistant Vice President, National Steel Corp., Pittsburgh, Pa.

**"Benefits of Purchased Oxygen to the Indiana Harbor Works of the Inland Steel Company,"** by N. R. Kirkdoffer, Superintendent, Power, Steam and Combustion Depts., Inland Steel Co., East Chicago, Ind.

**"Economics of Generated Versus Purchased Oxygen for Steel Plant Use,"** by R. A. Lambert, Superintendent, Steam Efficiency and Combustion Dept., Pittsburgh Works Div., Jones & Laughlin Steel Corp., Pittsburgh, Pa.

**"Oxygen Plant Cycles Tailored to the Requirements of Iron and Steel Producers,"** by Clarence J. Schilling, Vice President and Chief Engineer, Air Products, Inc., Allentown, Pa.

**"Operation and Maintenance of a 100-Ton Double-Cycle, Gaseous Oxygen Plant,"** by G. T. Wright, Mechanical Superintendent, Dominion Foundries and Steel, Ltd., Hamilton, Ontario, Canada

**"Maintenance Experience with Oxygen Plants at Sparrows Point,"** by A. Stutzer, General Foreman, Prepared Gases Station, Fuel Dept., Bethlehem Steel Co., Sparrows Point, Md.

### 2:00 pm—ELECTRICAL SESSION—
### Monongahela Room

Chairmen: R. T. Lucas, Electrical Superintendent, Weirton Steel Co., Div. of National Steel Corp., Weirton, W. Va.

C. L. Squier, Assistant Electrical Superintendent, Bethlehem Steel Co., Lackawanna, N. Y.

**"Recent Hot Strip Mill Roughing Trains,"** by John H. Greiner, Application Engineer, Electrical Application Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

**"Practical Aspects of Power Layouts for Steel Mills,"** by A. J. Mosso, Vice President, Auburn & Associates, Inc., Pittsburgh, Pa.

**"Constant Horsepower Computer—Permitting the Use of Slip Coupling for Winder Drives,"** by P. R. Gravenstreter, Electrical Engineer, The Clark Controller Co., Cleveland, Ohio

## LADIES PROGRAM

**Ladies Headquarters and Registration—**

**Hotel Penn Sheraton**
**Parlors E-F,**

**Monday, September 23.....Tea**

**Tuesday, September 24.....Luncheon**

**Wednesday, September 25.....Kaffee Klatsch**
**Formal Dinner**
**Dance**

Honorary Chairwoman: Mrs. J. D. O'Roark

General Chairwoman: Mrs. R. B. Schnure

Vice Chairwoman: Mrs. J. L. Young

To partially cover costs, a flat registration charge of $5.00 will be made which will cover all ladies activities except the formal dinner on Wednesday evening. This must be paid on registering, when tickets will be issued for these events.

# Hotel Reservation

Make your room reservation directly to the Penn-Sheraton Hotel, giving time of arrival, length of stay and type of accommodations desired. Reservations should state that they are for the AISE Convention. If the hotel is unable to take care of you, it will forward your request to the Pittsburgh Convention Bureau, who will place you elsewhere. Penn-Sheraton rates are: single room, $8.00–$11.00; double room, $12.50–$14.00; twin room, $13.50–$19.50.

**View shows new Mellon Square in downtown Pittsburgh. At right is Hotel Penn-Sheraton**

# A New Static Control System

By
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*. . . . static digital control systems add another tool to the kit of the electrical control designer . . . . as a result, operators in the iron and steel industry will be able to turn out a more uniform product at faster rates . . . .*

▲ EVER since its introduction to the steel industry shortly following World War II, the magnetic amplifier has made a performance record that becomes more enviable as the number of its applications continues to expand. After first developing a reputation as a precise yet rugged performer on military regulating systems, it is now recognized as the standard amplifier for most rolling mill and processing line applications. Its ability to meet the stringent requirements of tandem cold reduction mills, such as that shown in Figure 1, has previously been described before the AISE. See paper "Operation of Magnetic Amplifier Controlled Tandem Mills" by J. C. Peth and J. W. Brinks, 1955 Proceedings AISE. This is well known as one of the most exacting applications in the steel plant.

The one feature of the magnetic amplifier that has contributed most to its popularity in regulating systems is that it is completely static. A typical system for a tandem mill is shown in Figure 2. With no rotating parts, no bearings, and no commutators, and without the inherent fragile construction of electronic tubes, it is only natural that its record of reliability and low maintenance should be outstanding.

The number of magnetic amplifier regulating systems now in operation is measured in thousands, and many of these are applied in steel plants. This extensive experience with the magnetic amplifier as an industrial regulator formed the basis for further development leading to an entirely new type of static control system designed to replace control relays. This new system uses magnetic amplifiers to perform the same function as relays, but does so without electrical contacts, moving parts, or electronic tubes. It brings to relay type controllers the same outstanding advantages that the magnetic amplifier has brought to regulator type control systems.

It had long been known that the magnetic amplifier could be turned on and off to act as a switch, but one inherent limitation to that use of this device was the need for a circuit that would equal or better the speed of operation of the control relay. When this problem was solved, completely static switching type controls reached the practical stage. The operating time of these devices is now faster than industrial relays and speeds approaching ½ cycle on a 60-cycle basis are inherent in the design of systems presently available.

## LOGIC FUNCTIONS

Static type switching systems are composed of a small number of basic elements, none of which has moving parts, combined to perform specific functions. These functions, developed and used in the computer field for a number of years, are essentially building blocks that can be combined in a variety of ways so that the information fed into the control system results in a desired relationship or method of operation of the outputs of the control system. These functions are referred to as logic functions. No matter how complex a switching type control system is, it can be arranged and separated into combinations of four basic logic functions called *AND*, *OR*, *NOT* and *MEMORY*.

**Figure 1 — This four stand tandem mill is controlled by magnetic amplifier regulating systems.**

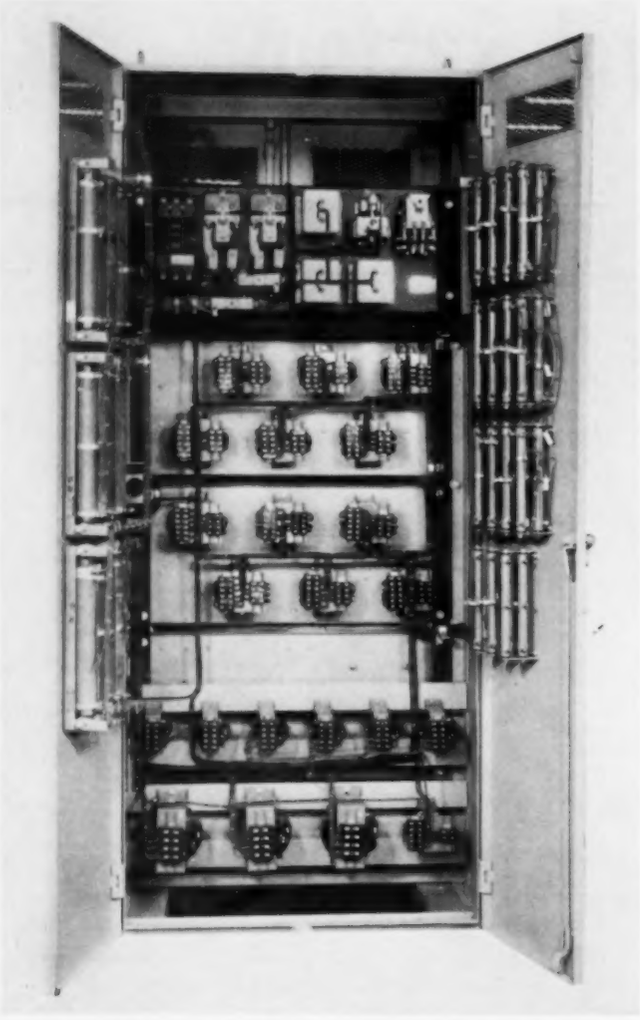


**Figure 2 — Magnetic amplifiers for one stand of a tandem mill regulating system are mounted in this control cabinet.**

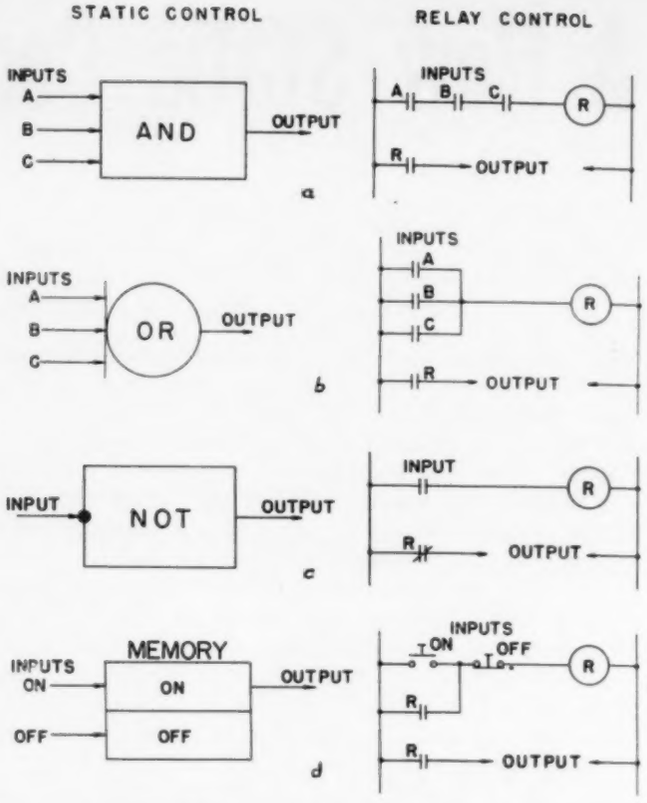



**Figure 3 — The *AND* function is shown in "a." Output appears only if input A *and* B *and* C are all present. The *OR* function is shown in "b." Output appears if either inputs A *or* B *or* C is present. The *NOT* function is shown in "c." Output appears only if input is *not* present. Output does *not* appear if input is present. The *MEMORY* function is shown in "d." Output appears when *ON* input is present and remains until *OFF* input appears. Output state continues (either *ON* or *OFF*) even though input signal is removed.**

Figure 3 illustrates these logic functions and shows how relays perform the functions by specific wiring arrangements. Static switching circuits perform these functions without the use of electrical contacts or moving parts. Combinations of static logic functions replace a complete relay type control system.

In Figure 3a, the *AND* function is represented symbolically in conventional relay terms and in static control terms. An output signal from the *AND* function will occur only when all the input signals are received. In this illustration, when inputs A and B and C are all present, there will be an output. In conventional relays, this would be comparable to a number of normally open contacts in series where all the contacts would have to be closed before the relay would be energized to give an output.

Input signals can originate from pushbuttons, limit switches, control relays, or static control components. Output signals can be used to operate other static controls, relays, contactors, solenoids or amplifiers.

Figure 3b illustrates the *OR* function. An output signal will occur if any one input is present. If either inputs A or B or C in the illustration are present, there will be an output. In relay circuitry, this is similar to a number of normally open contacts in parallel where any one closed contact will energize the relay to give an output.

The *NOT* function is illustrated in Figure 3c. An output signal will be present if there is no input. On the other hand, if there is an input signal, there will be no output. This, in conventional relays, is like a normally closed contact where an input signal will drop out the relay and stop the output.

The *MEMORY* function is shown in Figure 3d. After an ON input is received, an output will appear and will remain whether or not the ON input remains. The output will be turned off only when the OFF input is received. In relay circuitry, a similar situation would be a holding circuit around a pushbutton whereby pressing the ON button would pick up the relay and hold it through the seal-in contact until the OFF button is operated.

The logic functions are supplemented by time delay devices operating in the range normally required in industrial control work and by amplifiers used to step up the output of the units to the level required to operate a contactor, motor starter or solenoid valve.

Logic functions are packaged as shown in Figure 4 to make them readily usable by the control designer. The modules are encapsulated in a polyester resin and fitted with terminals on the upper and lower faces. The units are approximately 3 in. high, 2 in. wide and

2 in. deep and the modules plug into a specially designed power channel which supplies the required a-c power to the units. Connections for signal inputs and outputs are made with push on terminals at the top.

As with magnetic amplifiers, the components of these modules, as shown in Figure 5, are magnetic cores, rectifiers, and resistors. These are mounted on a printed circuit board about $\frac{1}{16}$ in. thick. The entire assembly is dip soldered to assure good electrical connections and then each unit is encapsulated to keep out oil and dirt.

Control systems using these static devices can be modified easily for circuit changes by adding or reconnecting modules. Hazardous atmospheric conditions are no problem, since there is no arcing or burning or other exposed flame. Static systems are compact and light weight and in most cases result in savings in space, particularly in the larger more complex systems. Since the systems have no moving parts, their life expectancy is not dependent on number of operations. They permit a degree of reliability previously thought unobtainable. All of these advantages add up to lower life time costs for switching type control systems, particularly for applications requiring repetitive operations or a multiplicity of contacts in a conventional relay system.

## APPLICATIONS

One of the first commercial applications of this new static control system is shown in Figure 6. This unit, in service in a large automotive plant in the Detroit area, controls a high production machine for automatically loading the vanes of a hydraulic coupling into the shell or torus. The machine operates on a fast repeating cycle, first feeding the vane, then indexing the shell, then feeding another vane, etc., until a total of 36 vanes are loaded into the shell. The entire series of operations takes only 29 seconds.

This unit went into service in November 1955 and has now recorded over 9,000,000 operations. On this high cyclic service, duplicate machines equipped with relay type controllers began giving trouble after six months operation. The unit equipped with static control, on the other hand, has been given only routine monthly inspections. This is typical of the performance possible with this radically different concept in on-off or digital type control systems.

Typical of the simpler, less involved application of static control in the steel industry is the one shown in Figure 7 for the flash trimmer on a pickling line. The static control in this instance was mounted in a conventional control center along with other controls for pickle line auxiliaries. Output amplifiers are shown in the panel at the upper left of the center. The logic elements are located in the lower panel, a closeup view of which can be seen in Figure 8. The power channel into which the logic elements are plugged is clearly shown in this illustration. The push-on terminals at the top of each module connect to input and output signals. The single control relay is not used in the repetitive sequence of operation; it normally operates only on initial start-up and provides the low voltage protection normally found on all controllers.

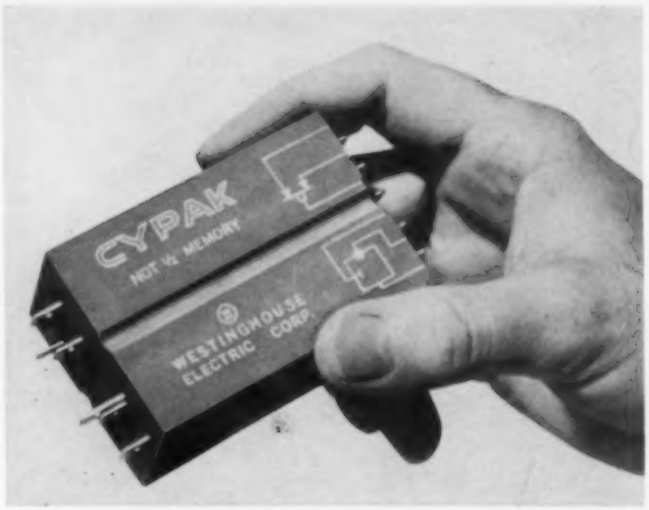



**Figure 4 — Static control logic elements are packaged to make them readily usable by the control designer.**

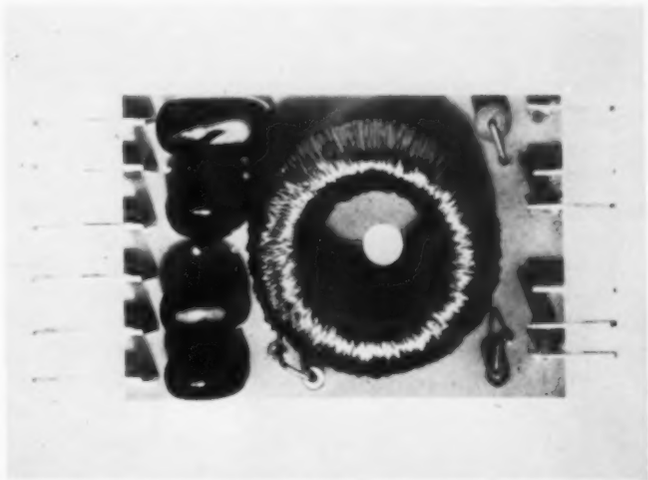
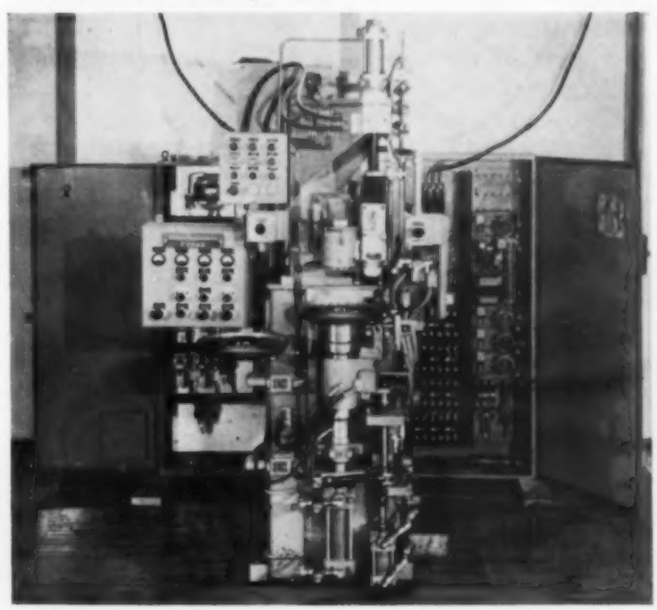


**Figure 5 — Components of static control modules are shown here before encapsulation. Magnetic core is at the center, rectifiers at left, and resistors at right. Components are mounted on printed circuit board.**

**Figure 6 — Static type switching controls have operated over 9,000,000 times on this high production machine in an automotive plant.**



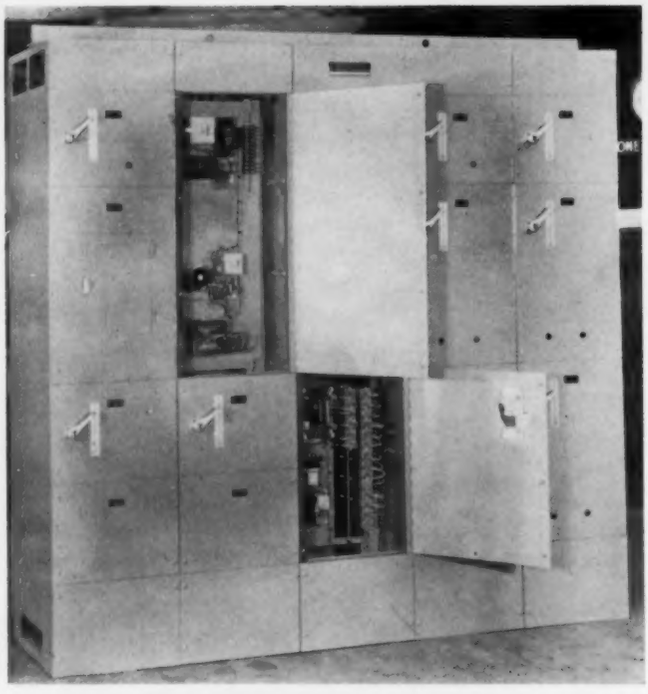


**Figure 7 — Static control for a pickle line flash trimmer is mounted in the control center with other auxiliary controls.**

The output amplifiers of this static control application work directly on the clamp solenoid valve and on the contactor coils of the reversing motor starter for the ram motor. The sequence of operation is as follows:

1. Cycle start pushbutton energizes clamp solenoid valves.
2. Ram begins foward "cut" stroke providing oil pressure is correct and clamp is down as indicated by one limit switch.
3. At completion of "cut" stroke, second limit switch reverses ram and unclamps.
4. At completion of "return" stroke, third limit switch stops ram ready for next automatic cycle.

*Blast furnace charging controls*—The control system which programs the sequence of operation of a blast furnace skip hoist and associated charging equipment normally consists of a large number of multi-pole control relays. Failure of any one of the relay contacts can interrupt the normal furnace charging sequence. Two furnace controls now being designed will go into service using static control to replace these relays.

The complete static control system for blast furnace charging is separated into two individual sections. The first section contains the logic elements and amplifiers for sequencing the coke system drives and hopper gate operators. The amplifiers work directly on the hopper gate solenoid valves and on the coils of the starting contactors for motors driving coke system loaders and coke bin feeders.

The second section of the control contains the logic elements and amplifiers for controlling the programmed furnace charging. It includes individual systems for sequencing the skip hoist, the distributor, the small bell, the large bell, the equalizer valve, the stock line recorder and the water system. The skip hoist operation itself is sequenced by static control by means of output amplifiers operating into the skip hoist speed control circuits. Manual control is possible on the hoist by means of master switches which override the normal automatic system.

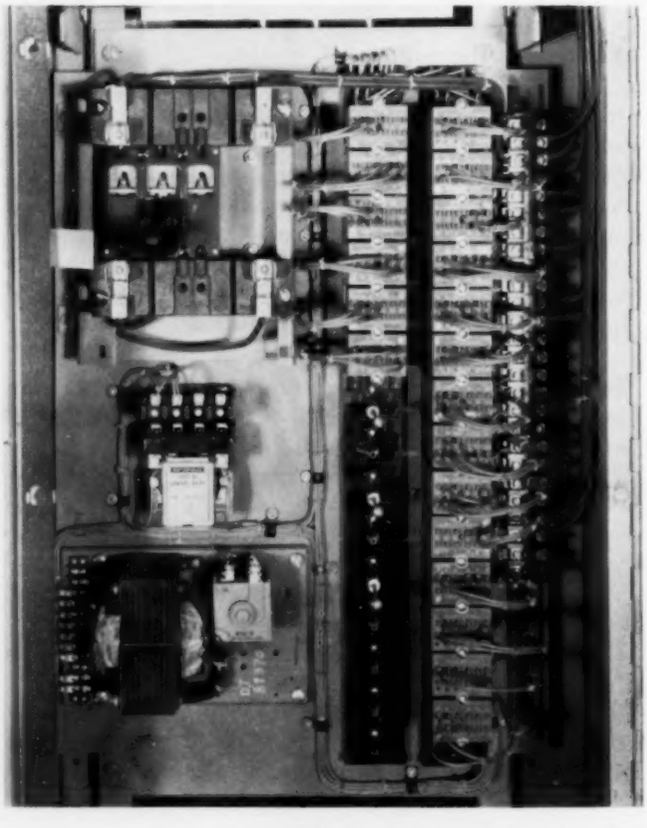
A typical automatic operation of the coke system begins when the skip enters the pit. Weight hopper gates open to fill the skip and then the gates reclose and the skip leaves the pit. The weigh hoppers then automatically refill, taking coke from different bins in sequence at each loading. One or more coke bins can be removed from service and the control automatically by-passes these units to fill the weigh hoppers from remaining units.

A typical operation of the furnace charging sequence control counts each skip as it leaves the pit, sets up a circuit to the coke and water controls to automatically load these materials when the skip next comes to rest in the pit, counts the number of skips to complete a loading schedule, and initiates dumping the large bell and advancing the distributor angle as soon as the last load has passed through the small bell.

*Funnel car for storage bins*—A system for controlling the unloading of bauxite storage bins at a west coast aluminum plant will soon be in operation. Static controls will sequence the operation of the funnel car, unloading gates, and dust removal system as illustrated in Figure 10.

Each funnel car services 24 storage bins and permits the bauxite to flow evenly to the delivery conveyor beneath the car. The control system automatically moves the car to one of the bins when the operator presses a button which selects the bin to be unloaded. Indicating lights show the position of the car at all

**Figure 8 — Close-up view of static control for flash trimmer shows method of mounting and wiring logic elements.**



times as it moves along the track. When it reaches the desired position, the control energizes the unloading gate and dust collector solenoid. Once the gate opens the car cannot move again until the gate recloses. Magnetic limit switches without electrical contacts are used at each stopping location of the car.

The complete static control system for this application consists of 628 logic elements, 24 amplifiers for gate solenoids, and 2 amplifiers for controlling the operation of the motor driving the car itself. The control is contained in a cabinet 100 in. long by 70 in. high by 20 in. deep.

It is interesting to examine the logic approach to the design of the control system for this application. In order for the car to be moved to say bin No. 1, the car must be at one of bins No. 2 through No. 24 as indicated by the limit switches being operated at one of these locations. In addition, all gates must be closed as indicated by outputs from the gate limit switches. Finally, the bin selector pushbutton for bin No. 1 must be operated. When all three of these have occurred, the car will move in reverse direction until stopped by the limit switch at bin No. 1. This suggests an *AND* function with inputs from the car limit switch, gate limit switch and pushbutton. The output from the *AND* unit would energize the *MEMORY* unit which continues to give an output even though the car moves off the limit switch or the pushbutton is released. The *MEMORY* output would be turned off by the limit switch operated by the car when the stopping position is reached. The output from the *MEMORY* would energize the amplifier which operates the contactor to start the car motor.

Movement of the car to bin No. 2 is accomplished in the same general fashion, except that forward movement of the car is caused if the car starts from bin No. 1 as indicated by that limit switch being closed. Reverse movement is caused if the car must start from any one of bins No. 3 through No. 24. It is readily apparent that in order to drive the car forward, a pushbutton signal must be combined with the output from a bin limit switch numerically below the number of the station selected. To drive the car in the reverse direction, the output of the selecting pushbutton must be combined with a signal from a bin limit switch numerically above that of the station selected.

One of the problems associated with conventional control for systems such as these is that a large number of multi-pole relays are required for sensing the direction the car must travel. A relay type system is relatively uncomplicated where relatively few stopping positions are involved. As the number of positions is increased, however, the complexity of the system likewise increases and the number of relay contacts become appreciable. Static switching controls eliminate these relays and the contact troubles inherent in these devices. Contact maintenance is particulary troublesome in this type of application due to the large amount of bauxite dust in the atmosphere.

*Ore sintering plant*—An interesting application now in the design stage involves adjustable voltage drives with sampled data type regulating systems for keeping constant the relative proportion of ore, flue dust and

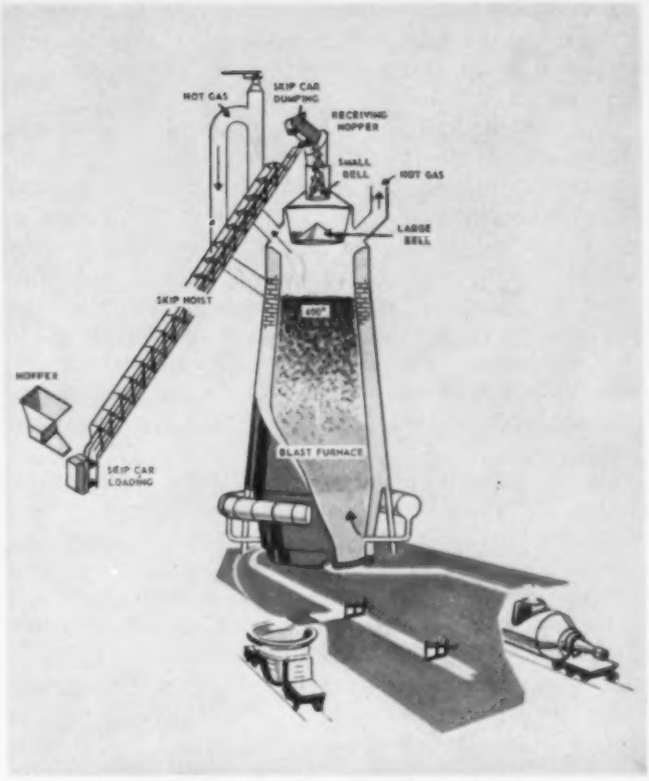



**Figure 9 — The automatic operation of blast furnace charging equipment is sequenced by static type controls.**

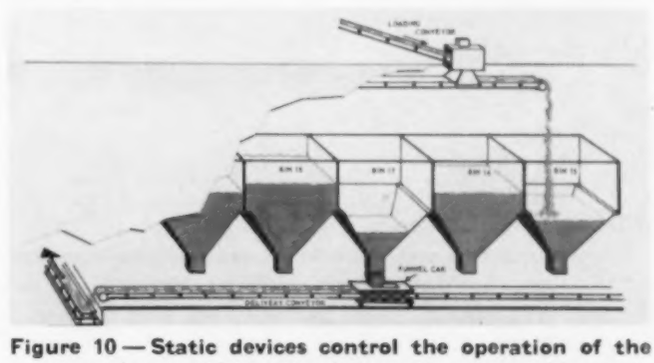
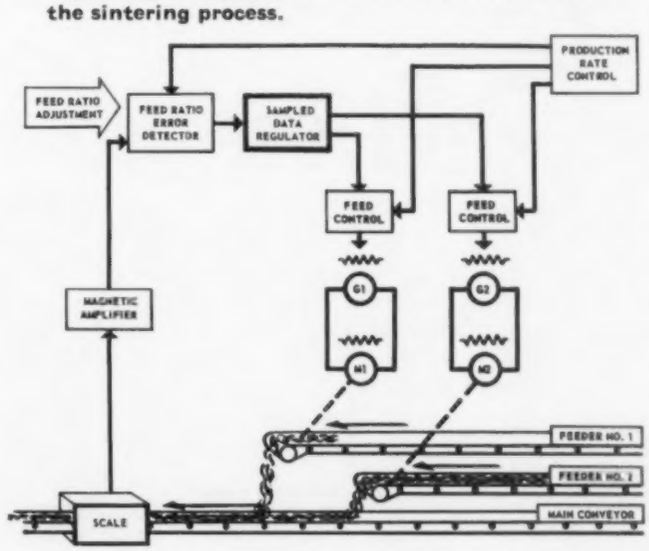


**Figure 10 — Static devices control the operation of the funnel car which unloads bauxite storage bins at a west coast aluminum plant.**

**Figure 11 — Block diagram of static switching system for regulating the proportion of ore and fuel delivered to the sintering process.**



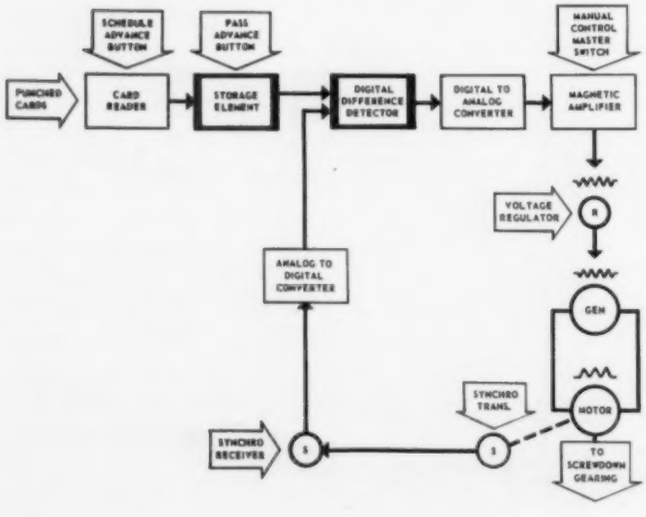
fuel delivered to the sintering process. Once a ratio of ore and fuel is set up, the operator can change the production rate and the preset ratios are held constant by the regulating system.

A block diagram of this application is shown in Figure 11. Automatic control is accomplished by continuously weighing the mixture of material passing over a conveyor and taking samples of this weight at periodic intervals. If the weight is not correct, the control system adjusts the feed of fuel or ore, then waits an appropriate interval of time for the new ratio of mix to reach the scales, then takes another sample to see if the previous correction was sufficient or too much. Switching circuits operate each time a sample is taken, after each time interval, and whenever a correction is made.

This is an application of a switching type control system operating in such a fashion as to give an end result similar to a proportional type of regulating system. The speed of response of the regulating system is dependent on the frequency of the sampling rate and on the width of the control band, which is the amount of change that can be tolerated without initiating a correction. The sampling intervals must be slightly longer than the time required for a change in feed to pass over and be detected by the scales. This time is called the transport delay. The amount of correction on each sampling interval must be less than width of the control band, otherwise over-correction would result. Sampling intervals must change automatically when production rates are changed since the transport delay also changes.

Each ore feeder and fuel feeder normally operates with two drives. The control system is arranged to operate with one correction interval when operating with both drives and to automatically switch to a longer correction interval if one drive should cut out. When large errors occur, a switching circuit automatically changes the regulator to provide a long time interval to get a large correction, until the error approaches the width of the control band. When this happens, the regulator automatically transfers back to its regular correction rate for slow final movement into the control band without overshoot.

**Figure 12 — Block diagram of automatic control system for programming reversing mill operations.**




Systems of this type can be operated using conventional relays. However, the frequency of operation is such that contact troubles can be expected to develop after a relatively short period of operation. Static control systems are a natural for this type of application since the number or frequency of the operations has no effect on their life or performance.

## AUTOMATIC MILL CONTROLS

As more experience is obtained in the techniques of static switching circuits, new and novel mill control schemes can be expected. One area in which considerable progress has already been shown is that of numerical programming of the sequence of operation of rolling mills.

A static control system of this type for the reversing roughing stand of a hot strip mill is now being installed. On this mill, the control system automatically sets the speed and roll opening of both horizontal rolls and vertical edger rolls for a complete rolling schedule. Another static system now in the design stage will sequence the complete operation of a reversing mill—including main and edger rolls, screwdowns, mill tables, feed rollers and manipulators.

In an automatic mill of this type, the rolling schedule is programmed on a punched card. Information for screwdown position, edger roll opening, mill speed, draft compensation, manipulator position and table speed is punched in the cards in binary number form. Space on the card not used for control purposes may be used for other purposes such as information for storing the card, job number and description, routing, etc.

In essence, a completely automatic mill control is merely a group of essentially duplicate control systems operating together. The individual system for the screwdown can be considered as a typical example of the control used for the other drives on the mill. A block diagram of a control system for the screwdown is indicated in Figure 12. That portion of the control beyond the magnetic amplifier is the adjustable voltage screwdown controller with rotating type voltage regulator and current limit control commonly in use today. Roll opening is indicated by a synchro or selsyn which gives an analogue type signal. This signal must be converted to digital or numerical form for use in the control system. An analogue to digital converter performs this function.

Information representing desired roll opening is fed from the card reader and storage element in digital form and compared with the digital signal representing actual roll position from the analogue to digital converter. The difference between these signals is the error between desired and actual roll opening. The digital difference detector makes this comparison and provides a numerical signal of the error by means of a counting circuit. This digital error signal is then converted back to an analogue signal by the digital to analogue converter, the output of which is impressed on the control windings of the magnetic amplifier which feeds the screwdown rotating regulator.

Here is the way a completely automatic mill equipped with this control would function. When the slab is ready to be worked, the operator inserts the card in a device called the card reader and operates the "schedule

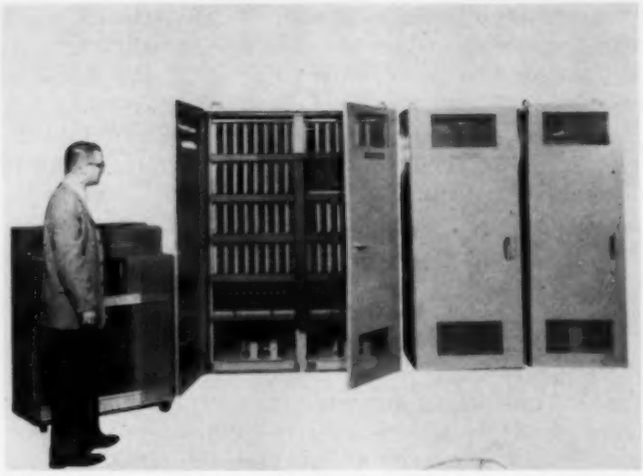


**Figure 13 — A static control system for programming reversing mill operations from punched cards is quite compact.**

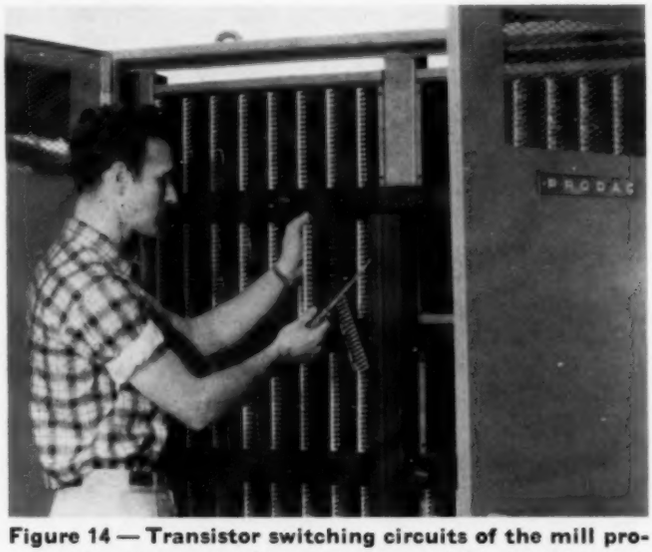


**Figure 14 — Transistor switching circuits of the mill programming control can be removed for maintenance and trouble shooting.**

advance" pushbutton. This causes the control system to "read" the card and store the card information in the storage section of the control. The operator then operates the "pass advance" button and the control "reads" from the storage section the information for the first pass, positions the screwdown and edger accordingly and sets their brakes. Simultaneously with positioning the screws and edgers, the control sets up the mill speed and draft compensation.

When these functions are performed, an indicating light shows the operator he is ready to start the mill. When the start button is operated, the tables, feed rollers and main rolls begin accelerating and the bar enters the mill.

As the tail end of the slab approaches, a hot metal detector, using transistors and a light sensitive silicon cell, detects the passage of the end of the slab and starts to slow down the mill and tables. As the slab leaves the mill rolls a strain gage on the mill housing indicates to the control system that the pass is finished. This automatically adjusts the edger and screwdowns to the correct position for the next pass and initiates the reversal of the main rolls and tables. Automatic rolling continues with each succeeding pass occurring in a similar manner.

The system permits the operator to over-ride the automatic control at any instant merely by moving his master switches. For instance, should difficulty be encountered in entering, the operator takes over control by operating his own master switches in the conventional manner.

Figure 13 shows the static digital control system for a mill with automatically programmed screwdown and edger. This control system uses transistors for switching circuits instead of the magnetic type units previously described. The choice of components in this case was dictated by the required speed of operation of switching and counting circuits as well as by consideration of space and cost.

A closeup view of the control cabinet containing transistor switching and counting circuits is shown in Figure 14. This section of the control consists of a number of duplicate circuits, each mounted on printed circuit boards which can be easily removed for maintenance and trouble shooting.

## SUMMARY

The static digital control system described in this paper adds another tool to the kit of the electrical control designer that will permit engineers of the iron and steel industry to make better, more uniform steel at faster rates. It is a versatile tool and yet a simple one requiring essentially no maintenance. It is apparent that the development of static switching paves the way for control systems far advanced from those in use today. The possibilities of combining static switching systems with static regulating systems opens up entirely new horizons in the field of industrial control. The electrical manufacturer stands ready to co-operate with the iron and steel producer in the design of new systems of mill control using these new techniques.

# DISCUSSION

**PRESENTED BY**

**KARL KUMMANT, Superintendent Electrical Dept., Mannesmann Tube Co. Ltd., Sault Ste. Marie, Ontario, Canada.**

**FRANK C. FENNELL, Manager, Central Region Engineering, Westinghouse Electric Corp., Pittsburgh, Pa.**

**HENRY BEACH, Supervisor Industrial Engineering, Ford Motor Co., Dearborn, Mich.**

**JOHN D. LEITCH, Vice President, Engineering, Electric Controller & Mfg. Div., The Square D Co., Detroit, Mich.**

**Karl Kummant:** Is it possible to give a cost comparison between a particular installation with static components and one with dynamic switching components?

**Frank C. Fennell:** To make a precise cost comparison between static and relay controls is not easy as the cost may vary considerably, depending on the application. We have found that some static systems will run only slightly more than relay controls; other systems may cost as high as three or four times.

The principal item that determines the cost of static systems is the output amplifier—and the more of these we have, relatively speaking, the more expensive the system will be. A control system that has a relatively simple relay circuit and a large number of outputs requiring amplifiers will probably be quite costly to build using static components. On the other hand, a system that requires a lot of relaying and has only a few outputs will give a much more favorable cost comparison. The bin funnel car system described in the paper is a good example of this type. It has a large number of inputs from limit switches and pushbuttons, but has only two outputs to the forward and reverse contactors that move the car. Of course, we should not forget that for many applications the higher first cost of static controls is more than offset by reduction in maintenance costs and downtime. All of the factors that affect cost should be considered in comparing one of these new systems with conventional controls.

**Henry Beach:** In the application of the automatic screwdown and table control on a blooming mill, would there be any savings in the time required to roll an ingot?

**Frank C. Fennell:** Some savings in time would probably occur where you have a repetitive type of operation such as a large order with one size slab rolled to the same final dimensions. Such savings could result because you repeat your operations precisely with a minimum of lost time. You set up your schedule and it repeats exactly the way that the preset schedule calls for.

As you know, a roller will sometimes misread the dial, and take two in. where he meant to take off an inch and a half, and the next pass maybe he only takes a half inch where he meant to take three quarters. This points out the real advantage of this new system—uniformity of the end product. The metallurgical properties of the steel are much more uniform when you follow the same precise rolling procedure each time.

**Henry Beach:** Could these automatic control devices be installed so that a reduction in manpower can be effected? I am thinking that perhaps with these automatic controls fewer people would be needed, i.e., could one man operate both rolling and manipulating controls?

**Frank C. Fennell:** I do not have any knowledge of cases where installation of equipment such as this resulted in a reduction in crew size. However, I think a reassignment of duties of the crew might logically be expected.

Although this equipment permits full automatic operation, I doubt that you would consider rolling without any operator. There is always the possibility of trouble in entering the bar in the mill, or in having the manipulator flip the bar over. From a practical standpoint, I believe you would have to continue to use your operators although combining or reassigning duties might be a possibility.

**John D. Leitch:** I would like to say a few words on this subject because it is one with which I have had considerable experience. During the last twenty years, our company, has designed about fifty automatic preset screwdown controllers. They are now in use in Australia, Luxemburg, Japan, England, Canada and the United States.

During these twenty years, many improvements have been made, each contributing to the speed and accuracy of the positioning control. The scheme which Mr. Fennell showed on the slide is essentially the same as that used by our company except for the digital or static control components.

The first installation was made on a plate mill at the Homestad Plant of the United States Steel Corp. in Pittsburgh in 1936. The latest version was shown at the Iron and Steel Convention in Cleveland in September 1956, where the programming is controlled by means of punch cards.

The first installation in 1936 used telephone plugs and jacks on the schedule panel and a contact-making ammeter to determine the stopping position. About 1946 the contact-making ammeters were replaced with electronic anticipators and detectors, the anticipators providing slowdown prior to reaching the stopping position, while the plugs and jacks on the schedule panel were replaced with a plug-in board which eliminated the cords. Later, the electronic anticipators and detectors were replaced with magnetic amplifiers and the schedule panel was further simplified by the use of sliders, while the latest version replaced the slider panel with punch-card readers.

Most of the applications of automatic pre-set screwdown controllers have been on plate mills without edger control. In some cases, both the edger and horizontal rolls have been controlled by automatic pre-set controllers. The scheme has also been applied to three or four blooming mills with success. Recently we have furnished three automatic pre-set screwdown controllers operated by a single push button on the finishing stand of a reversing beam mill. In this case the horizontal rolls, edger rolls and vertical rolls are all automatically pre-set for each pass. One man is able to operate the entire mill, reversing the rolls and the tables manually, while positioning the three screws automatically. This would be quite impractical if each of the three screws had to be operated manually. Controllers for two other such mills were recently shipped to England.

In answer to Mr. Beach's question, I do not think he would want to run a mill without anyone present in the pulpit. We have not reached that stage yet in our automation program. The speeds obtained by automatic positioning control of the rolls is about equal to that of a good operator doing it manually, but without the fatigue and the subsequent inaccuracies which result therefrom. However, we must not look only at the speed of the screws in determining the overall efficiency of the mill. There is certainly no use in speeding up the roll movements, only to wait for other events to take place. It is much easier on the machinery, motors and control if we do not accelerate and decelerate too quickly. In driving a car there is certainly no sense in attaining a speed of 100 mphr, when you know you will be compelled to stop and wait for a light at the next block.

I remember a case in which a customer had one of these automatic pre-set screwdown controllers installed for a number of years and because his production had fallen off somewhat, he had the speed of the pre-set screwdown controller investigated. It was very easy to prove that nothing would be gained by increasing the speed of the screws until he had increased his production four-fold. The delays, and there were many of them, were elsewhere.

*. . . . sintering, which was primarily an art, is now becoming a scientific process . . . . the team approach is resulting in better designs . . . . originally a non-ferrous operation, it has become a fundamental process in the steel plant and many more lines will be needed . . . .*

# SOMETHING NEW IN SINTERING

By
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▲ TO know sintering one must look into past history and the developments of the nonferrous work which preceded the ferrous work. Otherwise one cannot see the developments of the past and may have to relive its mistakes.

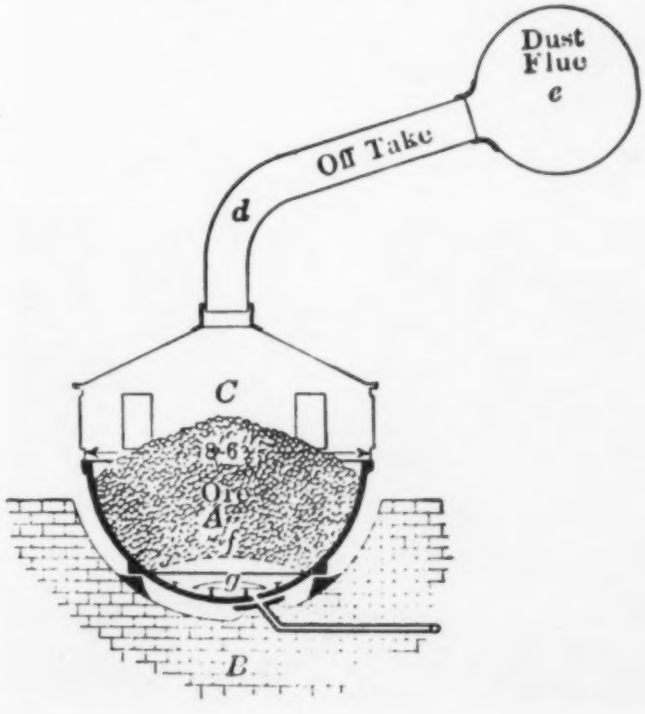
We sometimes wonder just what sintering is. The combustion engineer may think of it as the art of burning a fuel containing up to 95 per cent ash, but for this paper let us use as a definition, "To cause the agglomeration or binding of grains of material into a porous clinkerlike mass by heating them to a state of incipient fusion while in a quiescent state."

The Huntington & Heberlein pot may be looked on as a starting point. The charge (Figure 1) was bedded down, bottom ignited and air was blown through for a long time, the product was something like some of our sinters. When the pots were dumped, great volumes of smoke and dust arose. They were sulphurous and bore deadly lead fumes. Even in the late 1800's, men began to rebel against this and the heavy sledge hammer breaking of the massive semi-metallized chunks of agglomerated materials into furnace charging sizes. It was also evident that a batch type of operation could not lend itself to efficient operation in the American methods of straight line production which were just beginning to show up.

These problems started a search for a continuous method of sintering without the back-breaking work and dangerous fumes. Using the pot as a basis the designs went through the various phases shown in Figure 2. Updraft was tried, then downdraft under pressure. It was seen that a round section vessel would not be feasible for the moving strand of pallets and the design was changed to the rectangular vessel shown in Figure 2c. Then downdraft under pressure was tried with good results but with some trouble in feeding and igniting the charge. Downdraft as in Figure 2d looked good but troubles from upper bed moisture condensing in the lower layers and forming a water barrier to gas passages were encountered. Some evidence of heat damage to grate bars was also apparent, so the draft on the vessel was reversed.

Fluidizing of the bed occurred, volatiles were driven off and the charge calcined, but movement of the particles as the zone of sintering heat passed through them prevented the essential agglomeration from occurring. A final effort using updraft was tried as in Figure 2e, placing a screen over the bed. If a light screen was used, they had to use low air flows to prevent fluidization and if a heavy screen was used it packed the

**Figure 1 — Sintering was originally a batch type process carried on in a round pot.**



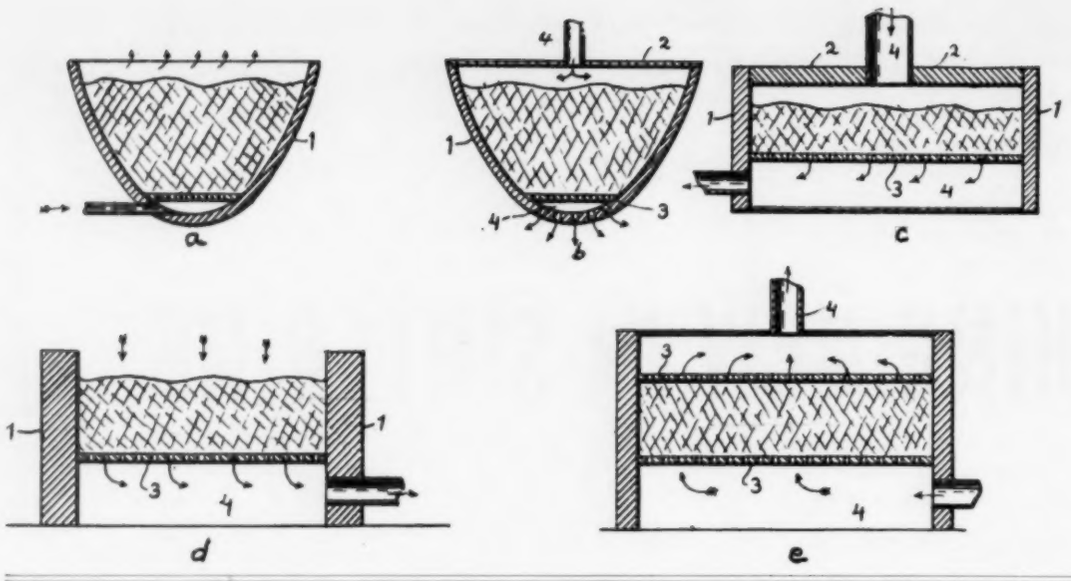



**Figure 2— Sketches show evolution of sintering from pot to rectangular grate.**

bed and destroyed permeability. Suction downdraft was finally selected and the first continuous machine was built.

This machine (Figure 3) was operated by turning the hand crank which pushed the pallet bodies ahead. At intervals, the crank was backed off and new pallets put on through the opening at the back. Material was shoveled on through the rear opening on top and smoothed down with a wooden paddle. Ignition was by a hand blow torch through the other top opening. The blower in front of the machine furnished the suction.

R. L. Lloyd, the co-inventor, is shown (Figure 4) feeding the machine on its first day of operation. The feed section, ignition section, sintering section with its windbox below and the cooling section can be plainly seen. The pallets just fell off the end. This was the culmination of the first big research program in sintering and, relatively speaking, from this start everything developed has been "something new in sintering".

Figure 5 shows the first commercial continuous machine designed and built. It has a hearth layer hopper, a feed hopper, an igniter and then a sintering section. Above the sintering section, a hood helped recuperate heat and control dust and fumes from the sulphur bearing charge.

Later there was a round table machine (Figure 6). Pallet (5) or grate bar sections were wedge shaped and received the charge from a feed hopper (19). As the table slowly rotated clockwise, the charge passed under an ignition burner (20) and then over the sintering section. Each pallet was supported on a shaft which had a pinion (21) on its outer end. This engaged with a rack (22) and dumped the sinter cake (4).

This circular machine has been the basis for design of a successful circular cooler now in use at the Appleby-Frodingham plant in Scunthorpe, England. George Elliott, the manager, was about to build a third sintering plant. He had learned that if all his ores, running about 30 per cent iron, were sintered and air cooled, he could make up his furnace charge in the sintering plant and secure optimum iron production.

Elliott had four rather new coolers of the curved wharf type known as the Fontana cooler in his second plant, but they were not able to do the work he required, so he looked back into non-ferrous history and found this circular design which could be placed on his existing foundations as well as be used in his new plant.

The four coolers in his new plant are shown in Figure 7. They lie in front of the machines. Sinter comes down a chute to a rather efficient hot screen, where fines are

**Figure 3 — Old sintering machine was operated by turning a hand crank.**

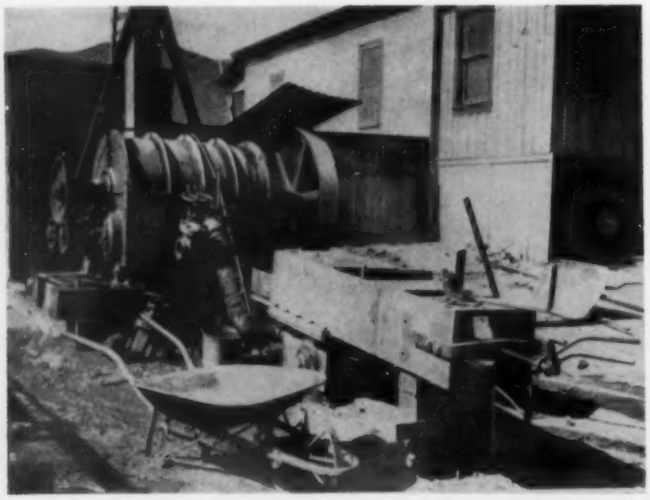


**Figure 4 — Illustration shows machine in first day of operation.**

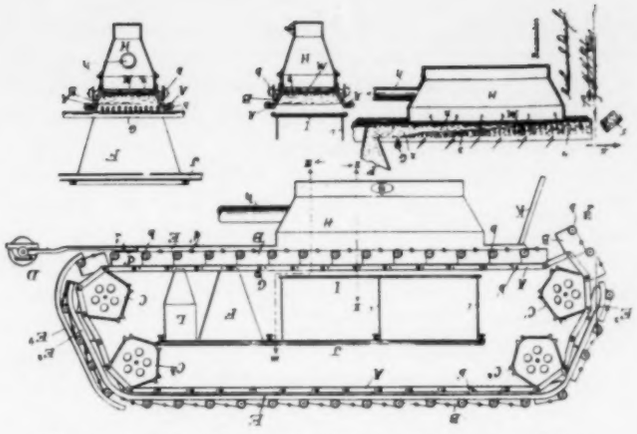


**Figure 5 — First commercial continuous machine.**

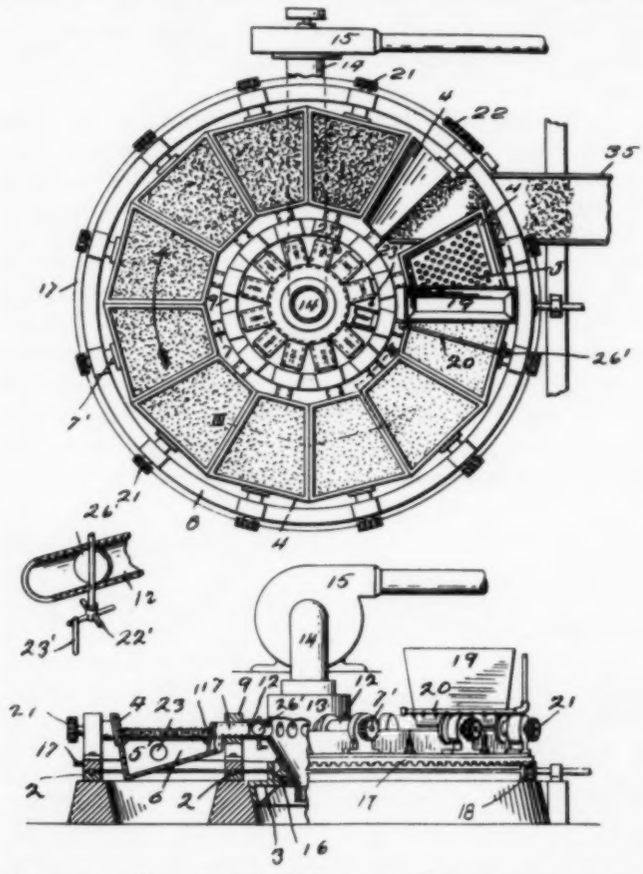


**Figure 6 — Round table design was also used many years ago.**

removed, passed through a water quench pugmill, and then go back to the feed as returns. The oversize sinter drops on the cooler and air is sucked through it as the cooler revolves. The wedge-shaped grate tips and drops the cooled sinter to a belt which carries it to the blast furnace bins.

Another early machine (Figure 8) looked a lot like the drum string filter. Charge material was fed from the hopper just visible to the rear and ignited as it came up to the top of the drum. Suction air was pulled through the drum by use of a windbox located under the sintering section and the finished sinter was scraped off the descending drum face by the curved grizzly bars in the foreground. It was early evident that none of these types could be the final design because of their limited capacities and because they could not be en-

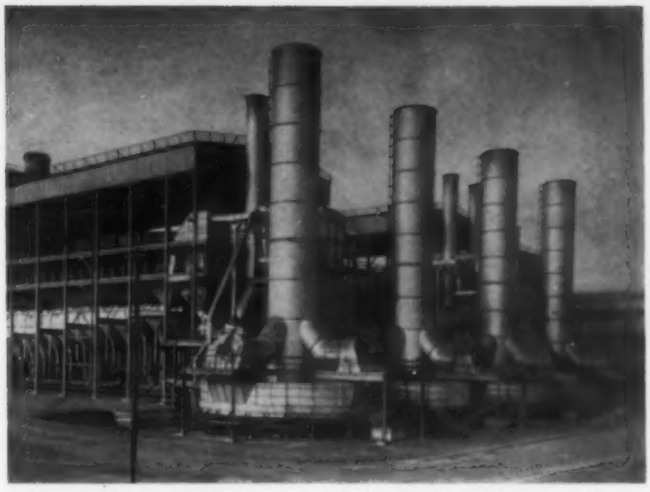
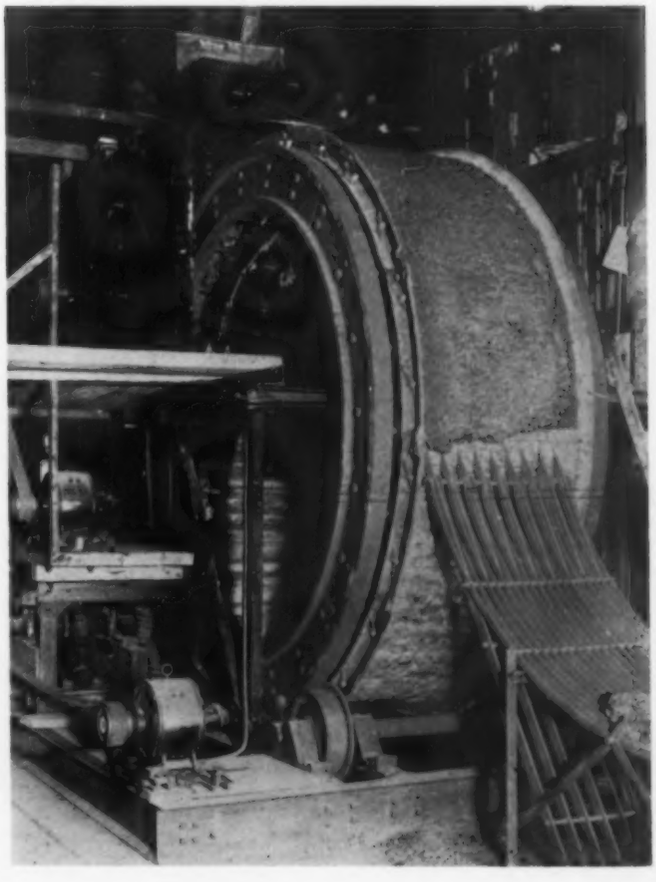


**Figure 7 — Circular coolers are now in successful use in the Appleby-Frodingham Plant in Scunthorpe, England.**

larged once they were installed. Engineering experts were called in and from their efforts came the classic design shown in Figure 9, which has endured to this day, with its individual pallets pushed rather than pulled over the machine, as the most used piece of equipment in the world for continuous sintering. The machine has a drive end which contains the feed section, a windbox or sintering section which can be of any length and a discharge section.

So far the developments were all in non-ferrous sintering, but it was evident that if flue dust, and the fines which helped create it, could be aggolmerated in the

**Figure 8 — Another old sintering machine looked a great deal like the drum filter.**



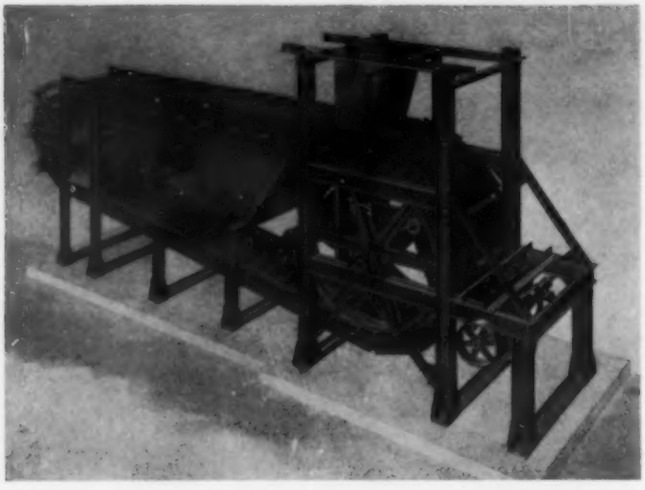


**Figure 9 — Classic design has endured until this day.**

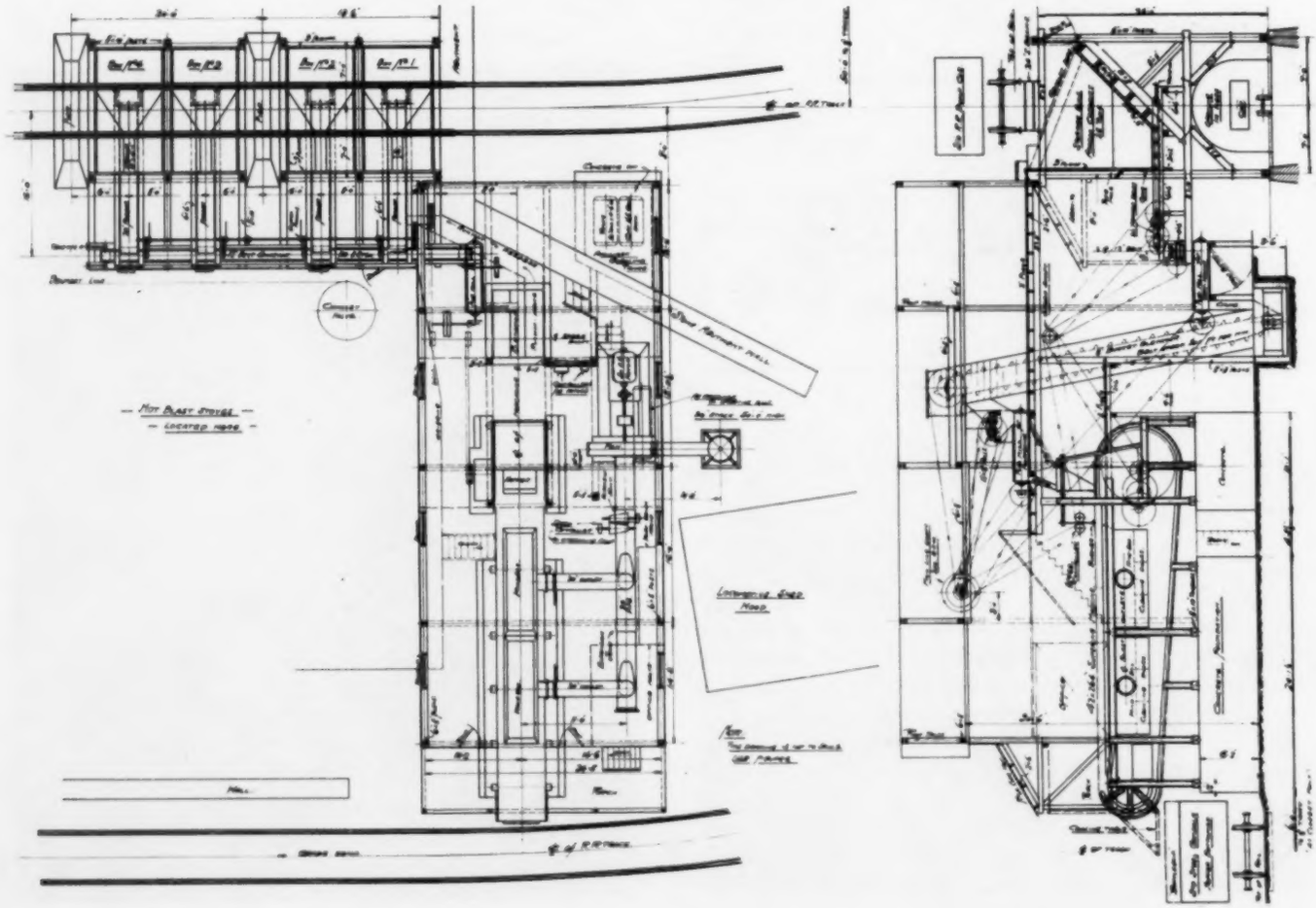
same manner, great improvement could be expected in blast furnace operations. The first big plunge was taken by the E & G Brooke Iron Co. of Birdsboro, Pa., and a plant (Figure 10) was laid out. This pioneer design might be called a "shot in the dark." Bins can be seen, each with a feeder below and then a collecting belt which discharges into a primary or dry mix pugmill and on into an elevator discharging into a secondary or moistening pugmill through a set of rolls to break up the lumps from the primary pugmill. The secondary pugmill fed the machine, which discharged over a cooling table to railroad cars.

The plant was old fashioned by today's standards with its wooden buildings and bins. Even the pugmills (Figure 11) had wooden sides, but much of the design equipment of the reasonably modern ferrous plants can be seen in this old drawing. Certainly some tremendous improvements have been made in the 45 elapsed years. Non-ferrous industries faced integration of sintering long ago, and today's economics will not permit the ferrous industry to do otherwise. The sintering plant must become a part of the full thermal reactions of a blast furnace plant.

To meet this need, ore processors are using a variety of tools. Instead of having one expert determine how a plant should be built, the job is studied by a group before any money goes into actual design and construction. This has brought "something new in sintering"—*the team* with all its members doing their individual jobs in a co-ordinated manner to meet the requirements of planned production in making apparently useless ores into useful metals.

It is unfortunate that research in sintering for many years lagged behind engineering and operations. Sintering is an old art of size enlargement during blast roasting. Usual divisions of size enlargement operations include molding, extruding, compacting, flocculating and fusing. The fusing systems have been applied in the basic industries that require a chemical transformation during enlargement, or synthesis of a hard durable product composed of firmly bonded contiguous particles. Nodulizing and sintering are two main schemes for size enlargement in the basic industries, using rotary

**Figure 10 — First ferrous sintering plant was constructed for E. & G. Brooke Iron Co. at Birdsboro, Pa.**



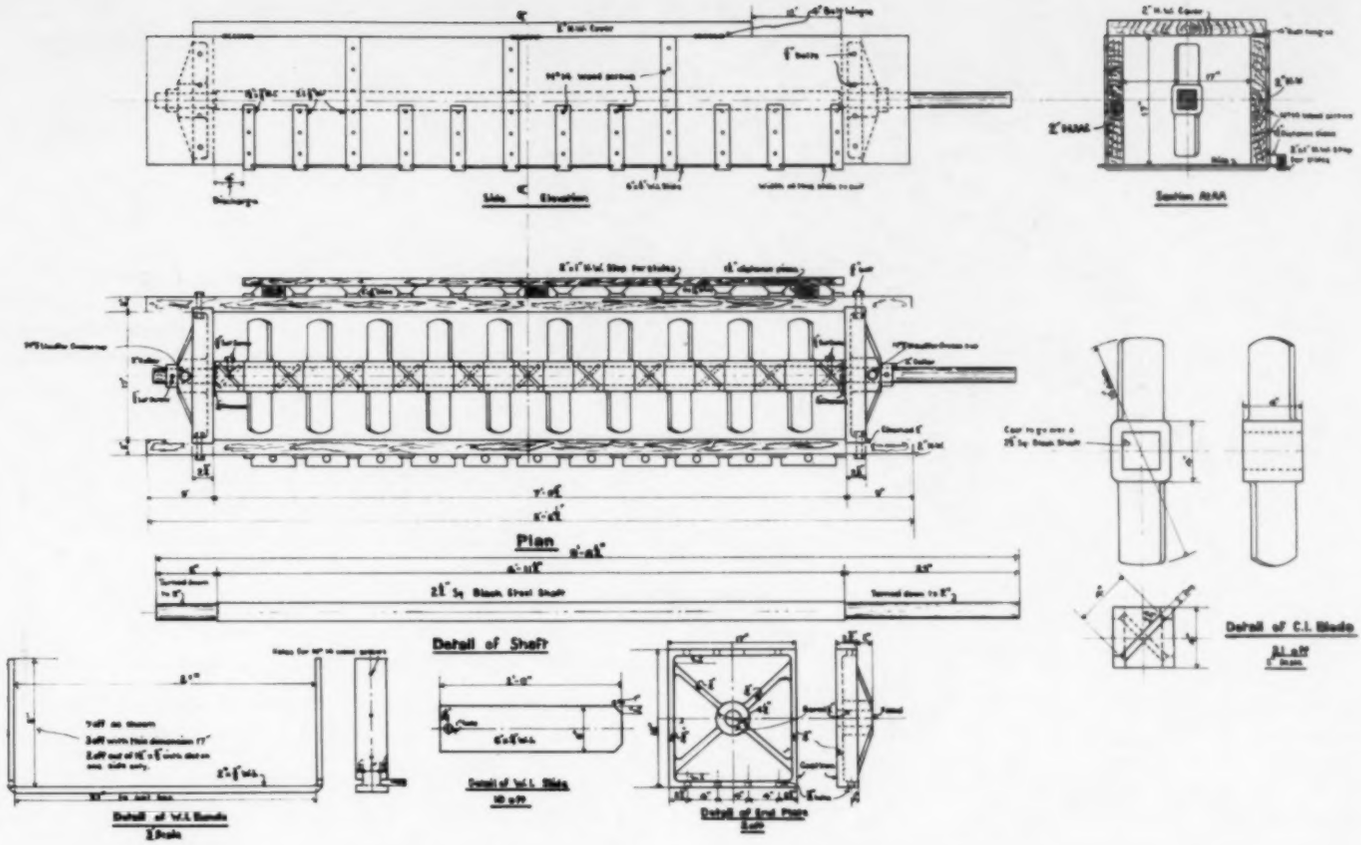



**Figure 11 — Old pugmill had extensive wood construction.**

kilns and traveling grate sintering machines respectively. Rotary kiln operations have been applied chiefly in cement and lime operations where chemical conversion through temperature control is requisite and traveling grate sintering machines have been applied in the ferrous and non-ferrous agglomeration schemes where large capacity units of lower thermal requirements are preferred. Iron ore beneficiation through sintering is accomplished by removing volatile constituents, improving the physical structure for gas-solid interaction and converting the material to a substance of relatively high thermal conductivity.

Sintering is a unique phenomenon of forming a hard cellular frozen foam from moistened particulate masses of ore and carbon. This is effected by propagating a heated air draft through the bed of blended solids and allowing a combustion band to dry, calcine, heat and partially fuse the bed, while the secondary draft freezes and cools the solids and transmits heat to form the combustion band. In iron ore sintering, this seemingly simple system can become complex. To properly test the response of various materials to sintering methods, the writer's company established a research laboratory with facilities for testing materials ranging from small 100-lb batch samples to continuous operations from carload lots. The small samples are tested on a mezzanine area. Carload samples for continuous flow are placed in a large bin, from which the materials are distributed to smaller proportioning bins and then gathered as a feed composite on a conveyor. The feed material is elevated to a balling or aggregating platform and into one of several devices. After aggregation, the material is fed to the sintering machine and the agglomerated product is discharged out of the building.

The sintering machine is a continuous reactor for gas-solid contact and as such can be used for either combustion or heat exchange. The laboratory machine has auxiliaries for operating under updraft and downdraft flow, with provisions for recuperation and cooling in both schemes. The duct arrangement for downdraft sintering is given in Figure 12. Air enters through the hood and exhaust is induced through metered windboxes to the dust collector and stack. Figure 13 shows the duct arrangement for updraft heat-hardening of pellets, using multi-layers of feed. Recuperation of heat is maintained in the cooling section, providing preheated air for combustion. Heat exchange of pelletized charges can be conducted with the duct arrangement shown in Figure 14, or the system can be used for downdraft cooling of sintering charges using the recuperated heat for the sinter draft.

A closeup of the proportioning bins (Figure 15) shows the belt feeders and a small feeder for adding minute quantities of additives.

Figure 16 shows the aggregating platform, where there are two devices, a pelletizing mixer and a flying saucer.

The flying saucer shown in Figure 17 uses novel principles for either balling fine materials with water or blending and aggregating coarser materials into an even-sized texture. In the latter case, it disperses solids intimately in the turbulent state while rejecting coarser sized fractions without excessive plating or accretion. In balling fine material, the flying saucer has a remarkable ability to produce closely sized balls without the necessity of using secondary classifying equipment.

Under conditions of continuity, measurements are made of solids flow as well as gas flow, temperature and

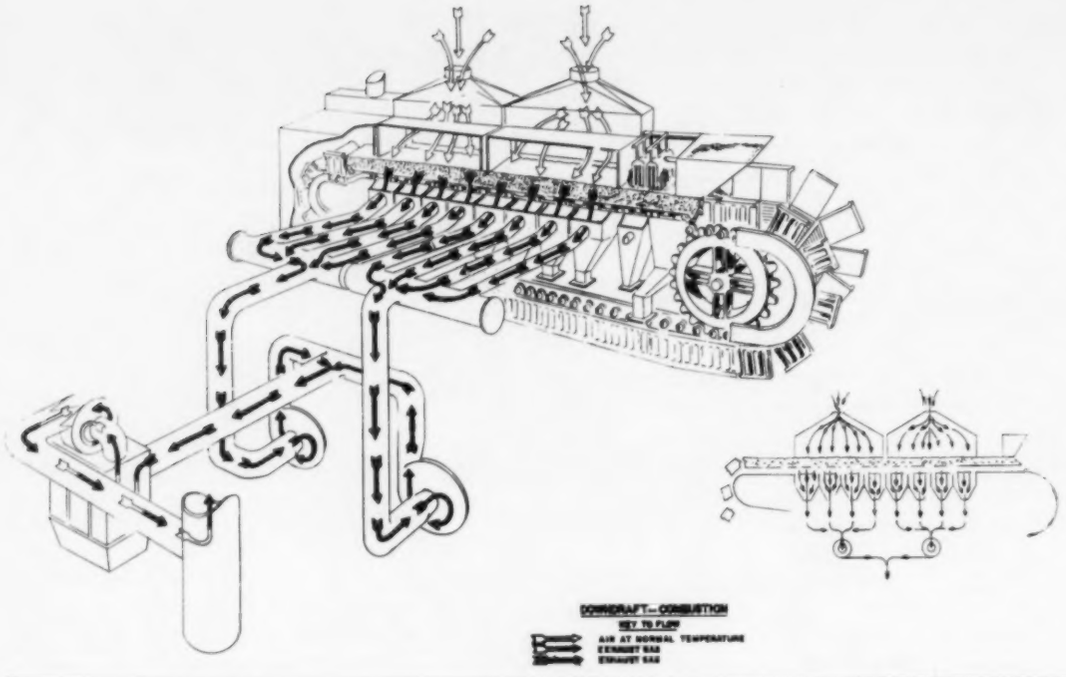



**Figure 12—Sketch shows downdraft combustion circuit.**

pressures in the laboratory sintering machine. These data, along with analyses of the quality of feed and product, are reported to engineering for design measures. The instrument panel has meters for obtaining these values. This panel also has a mimic flow sheet, along with interlock push-buttons, allowing the operator to observe and control the component pieces of equipment.

Prior to a continuous run in the laboratory, representative samples are tested in batches using smaller equipment.

Our research laboratory was built to provide a proving ground for tests that cannot be made in a commercial plant. Proven test data is obtained for application to the production plant.

This paper has already described some of the older machines. The remainder will cover a sintering machine of modern design.

Figure 18 shows many things new in sintering. This particular machine is presently being operated in the first updraft pellet plant in the United States, which was built on the upper Michigan peninsula for a large iron-ore mining company. The machine is essentially a big steel conveyor composed of a series of pallets, each of which on this machine weighs about 4000 pounds assembled. This particular machine runs from 1 to 4 fpm. We are presently designing a somewhat larger machine which will run up to 24 fpm.

This is a machine of many "firsts." It is the first updraft machine produced in this country, sintering as

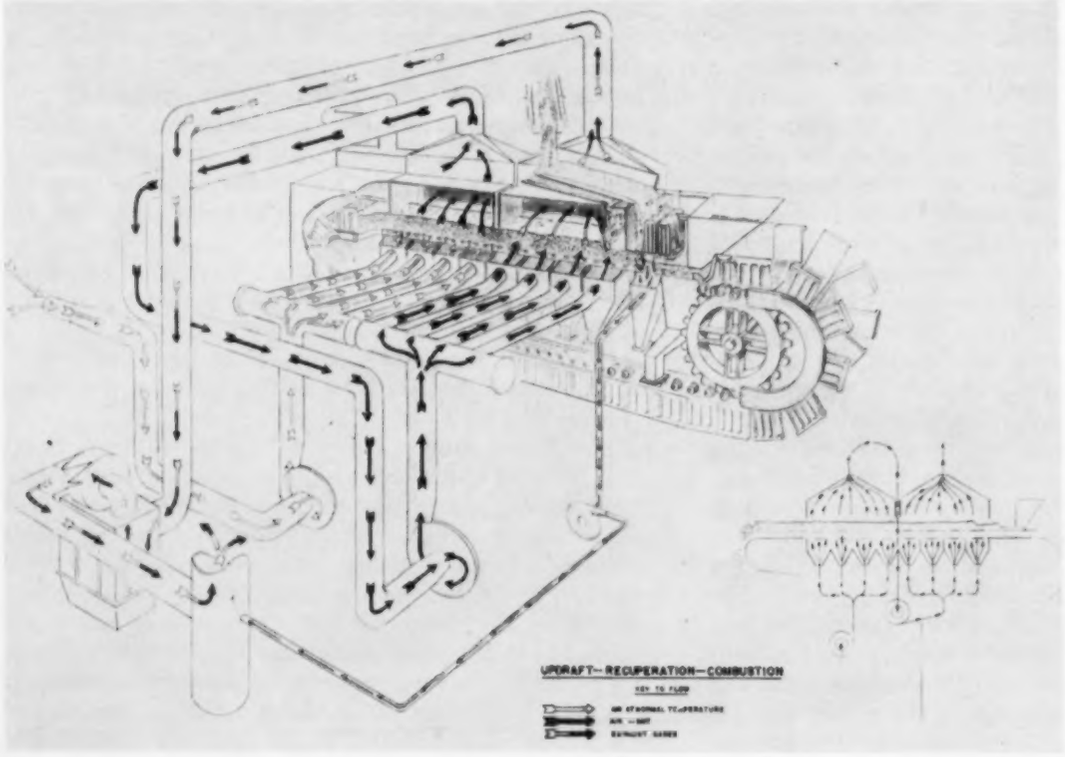



**Figure 13—Sketch shows updraft-recuperation combustion circuit.**

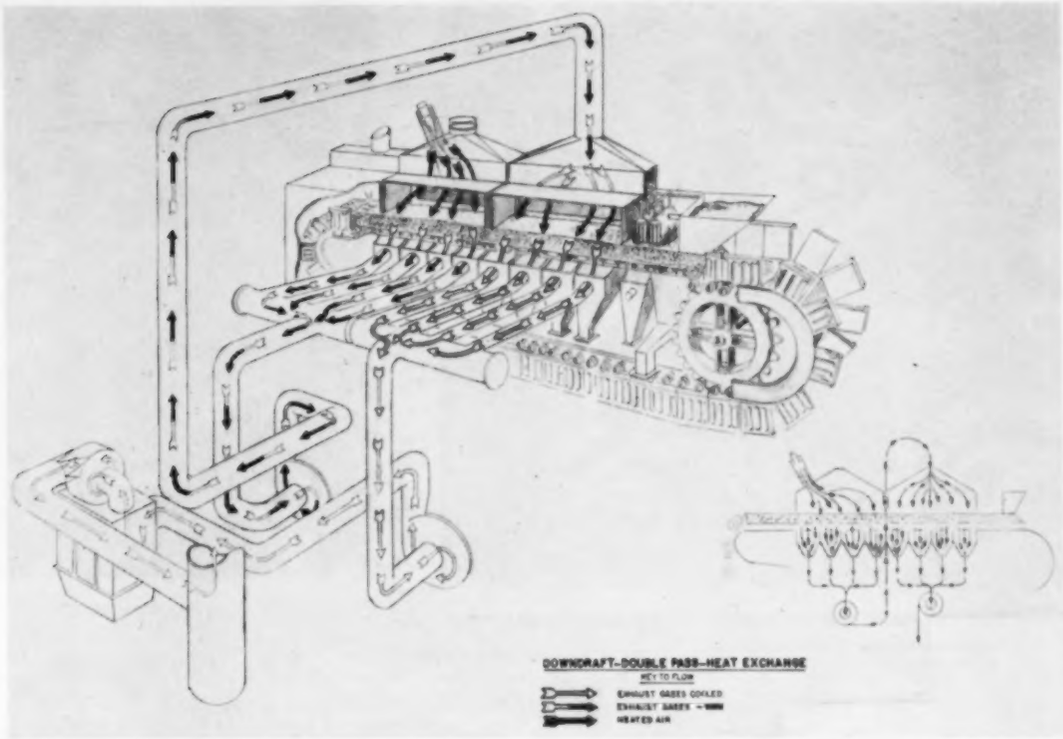



**Figure 14— Sketch shows downdraft-double pass-heat exchange circuit.**

performed today being generally a downdraft process. It is interesting to note that the first conception of sintering was as an updraft process which was unsuccessful, mainly due to inability to properly pelletize the feed with the machinery available at that time. Now with improved pelletizing techniques, we are back to updraft.

This is one of the longest machines in the world, having the over-all length of 233 ft. A 4-in. hearth layer of burned pellets is placed on the bed, moves under an ignition furnace and over a downdraft zone wherein the layer is brought to incandescence. The machine is fed in four layers by means of oscillating feeders which eliminate the traditional, troublesome swinging spouts. In this way the pellet charge is gently laid on the machine.

As the incandescent mass moves under the first feed point, airflow is transferred from downdraft to updraft, and thus combustion is transferred to the green pellets. This moving bed is timed so that the burn-through point occurs at the next feed point, and so on until four layers, each 8-in. thick, are deposited on the machine, giving a total bed depth of 36 in., the deepest bed ever attempted.

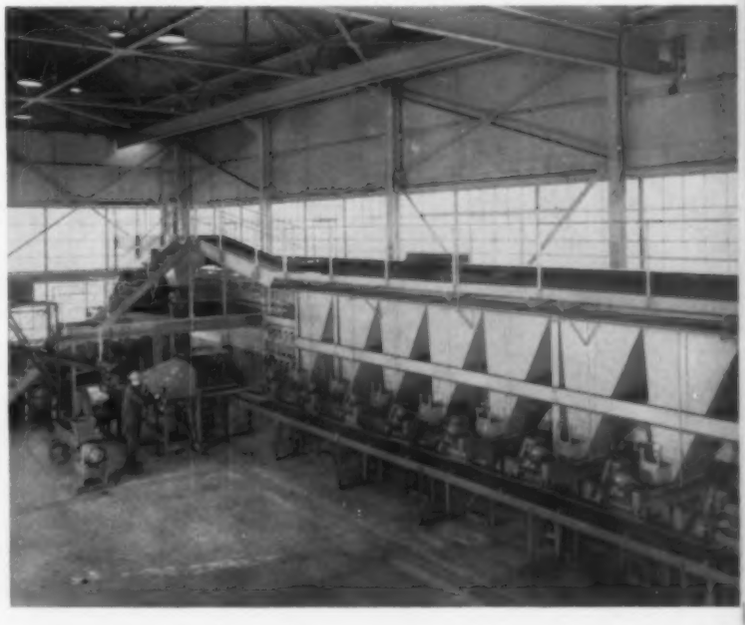
This application was first proved in the research laboratory. After burn-through of the last layer occurs, the updraft air is cooling the burned pellets. Finish cooling on the top of the bed is performed by transferring to downdraft in the last two windboxes. The burned pellets are "hand-cool" at the discharge of the machine.

The air performing the cooling action is raised in temperature to approximately 400 F and normally would be exhausted to atmosphere. Instead the heated air is collected in an exhaust hood and used as preheated combustion air in the initial stages. This results in significant fuel savings.

Features of the machine are the cast-steel trussed pallet design to better withstand the effects of stresses caused by heating and cooling impact, the pallet release which prevents pallet or tooth breakage upon misengagement of the sprocket teeth with the pallet driving hub, and the dual drive which is designed for smoother operation throughout the speed range without the characteristic racking and jerking so prevalent in other machines.

Figure 19 is a section through a similar sintering machine. In general, downdraft machines do not require hooding, but in updraft a hood is necessary for collection of the exhaust gases. Hooding of the section over the bed is not sufficient, and the necessity for operator-protection from possible blowout through the pallet side plates is obvious. A tunnel seal, operating in conjunction with the windbox seal, protects the operator, yet prevents dust buildup on the moving parts.

**Figure 15 — Closeup of proportioning bins.**



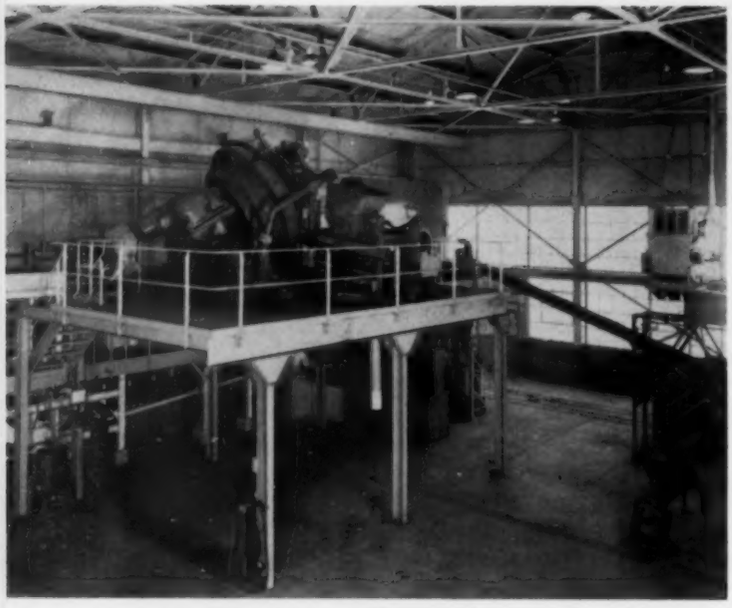


**Figure 16 — Materials are elevated to aggregating platform in laboratory by a conveyor.**

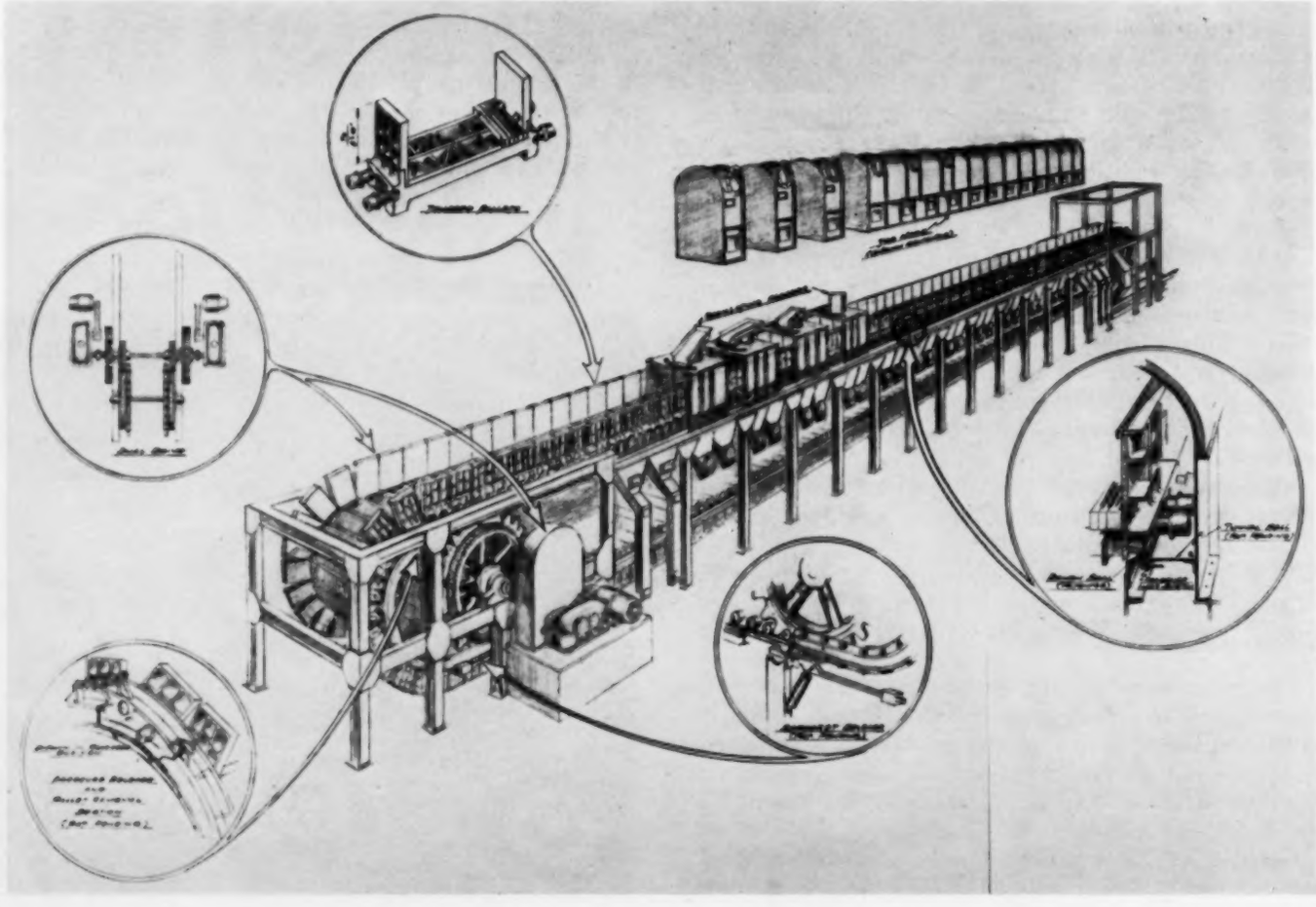
**Figure 17 — Flying saucer effectively balls fine materials.**

Air flow through the bed is, of course, a prime consideration and since the sintering fan is the biggest power consumer in the plant—running about 3000 to 3500 hp—it deserves particular consideration.

The factors which influence fan capacity are bed permeability, pressure and leakage. Bed permeability is controlled, limited of course by the specific material and by feed preparation. Pressure is determined by the demand for air-flow through the bed to sustain combustion. Leakage is controlled by the mechanical design of the system itself. Air infiltration into the duct system is the thief of horsepower.

Early sintering machines were equipped with a drop-bar seal which depended for its sealing action on gravity fall of a pinned bar attached to the pallet bottom against a wearing surface attached to the windbox. This seal has been used on most machines in

**Figure 18 — Machine shown is now being operated at an updraft pellet plant in the upper Michigan peninsula.**



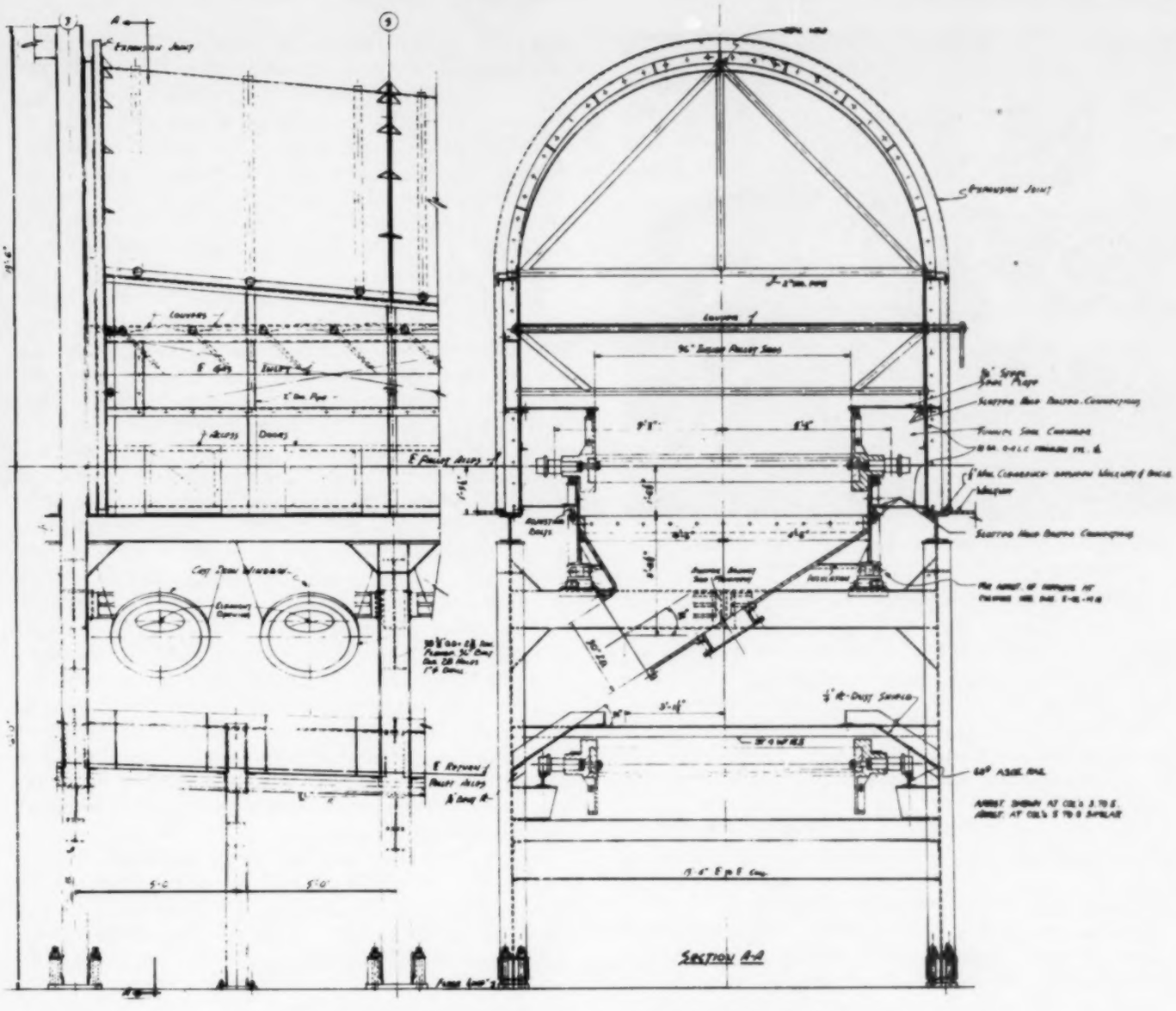



**Figure 19 — Section through updraft sintering machine.**

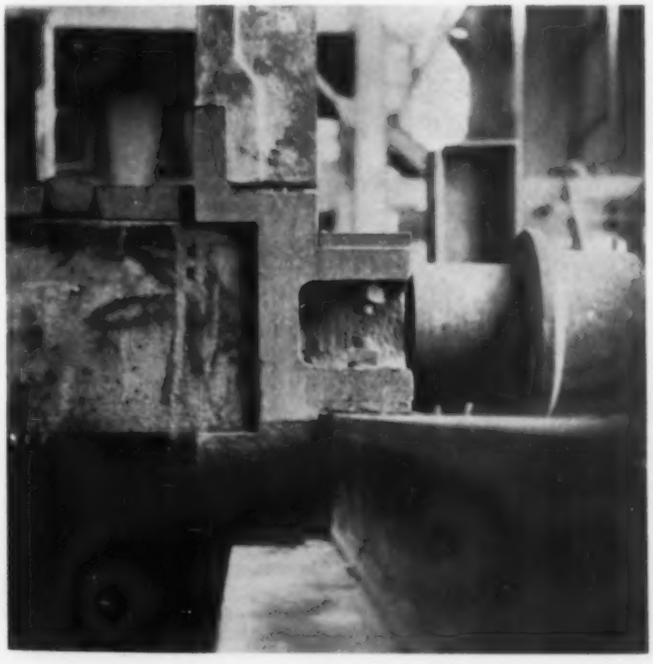
production today. In practice the drop-bar is found to require extremely careful maintenance in order to maintain any semblance of a seal and recent tests conducted by a major steel company showed higher than 50 per cent air leakage.

Our solution to windbox air leakage is the seal, shown in Figure 20, which tests have shown to cut leakage to approximately 5 per cent.

This seal has no moving parts and the entire weight of the pallets is supported on the windbox seal bar. Both the bar on the pallet and on the windbox are replaceable. The sliding surfaces may be lubricated by several means, one of which is automatic cyclic injection of grease through the windbox seal bar. Machines with this seal have been in operation for five years and less than $\frac{1}{16}$ in. of wear on the replaceable bar is reported. The wheels are free throughout the entire travel and are used on this machine only to return the pallet by gravity on the return side. This of course results in 50 per cent reduction in wheel wear.

While air leakage influences the economics of sintering, it has little bearing on the quality of the product, provided enough air is supplied to maintain proper combustion.

**Figure 20 — Use of seal shown has reduced leakage to about 5 per cent.**



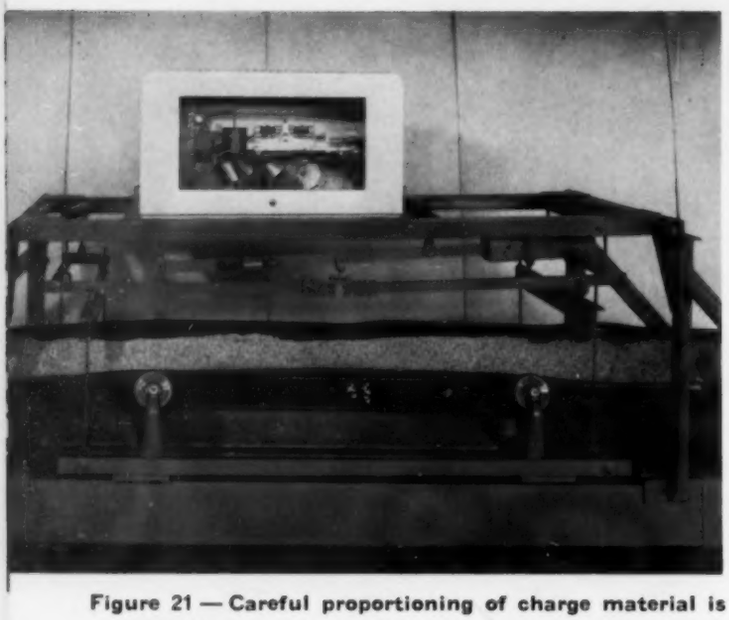


**Figure 21 — Careful proportioning of charge material is necessary.**

In the infancy of the sintering process, the development from crude batching methods to the continuous, proportioned mix plant was extremely rapid. Four years from the first attempt in 1907, there were in existence in the United States, complete continuous production plants embodying most of the features which contributed to the successful sintering plant of just a few years ago.

Proportioning control has always been present in nonferrous applications but was ignored in ferrous sintering, which for years was relegated to a dark corner of the steel plant as a necessary evil for reclaiming flue dust.

Our laboratory has confirmed the proposition that quality of sinter is not derived from the machine, but is determined by the care used to properly prepare the charge. Careful proportioning of the charge materials—ore, flue dust, mill scale, open hearth slag, fuel, fine returns, dust from the collection system and added moisture—is of paramount importance. We accomplish this by means of a proportioning feeder shown in Figure 21.

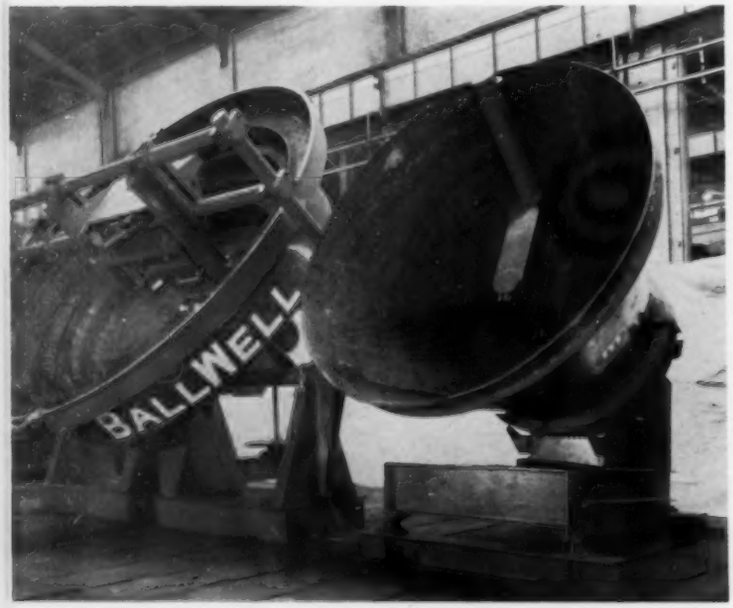
This is a belt feeder weighing device which runs at variable speeds, depending on the preset proportion desired. The weighing mechanism supervises the actual weight of material being delivered to the charge, holding it constant within narrow limits by controlling the speed of the table feeder discharging material from the storage bins.

The proportioned materials must be thoroughly mixed so that the charge is uniform throughout. Pugmills have been used since sintering began for this job and have proven themselves to be poor in efficiency and high in maintenance. When mother mixed a cake batter, she tilted the bowl and with her spoon set up a whipping turbulent motion in the batter. This action is used in the "flying saucer," a disc mixer-pelletizer which thoroughly mixes the mass and incidentally produces seed pellets of the fine materials. Experiments conducted by one steel company have shown a tremendous increase in production of an operating plant as a result of using one of these saucers to replace both primary and secondary pugmills.

Material is discharged into the disc, and water, proportioned by weight, is sprayed into the turbulent mass. Here is the mixing action of mother's cake batter, the material constantly folding upon itself, blending and reblending as it centrifugally moves out from the center. The saucer is more than just a mixer, however; it is also an efficient pelletizing device which gives great uniformity in pellet size.

Figure 22 shows some feed preparation devices. No machine is a cure-all for mixing or pelletizing problems encountered with all materials. For specular hematite, for instance, best results in pelletizing are obtained with a flying saucer; for other materials the cone seems to do a better job. The whys of the subject are a major concern of our research group. We do not confine ourselves to one device but seek the best way applicable to the behavior of the specific material.

**Figure 22 — Several feed preparation devices are needed for various type ores.**




The production saucer is 18 ft in diameter and is powered by a 75 hp motor. Four pugmills would be required for the same mixing capacity and would require approximately 400 hp. Those familiar with pugmill operation are aware of the constant blade maintenance required. Indeed, we do quite a spare parts business on such blades. It should be noted that, after one year's operation of the first flying saucer, no maintenance was required other than normal lubrication and there are no signs of wear on the machine.

The balling drum, while somewhat better than the pugmill, is extremely sensitive to minor variations in moisture content and, because of its mass, requires substantial horsepower for driving purposes. The drum is subject to build-up and the product lacks uniformity in size.

Figure 23 is an artist's conception of the two types of balling circuits in primary use today and illustrates the comparative sizes and complexities of equipment involved. The feed to the balling drum is from the table feeder under the feed bin via a conveyor to the balling drum. The random sized balls leave the drum and are delivered to a sizing screen. Undersized balls are relayed by a system of conveyors back to the entry. Properly

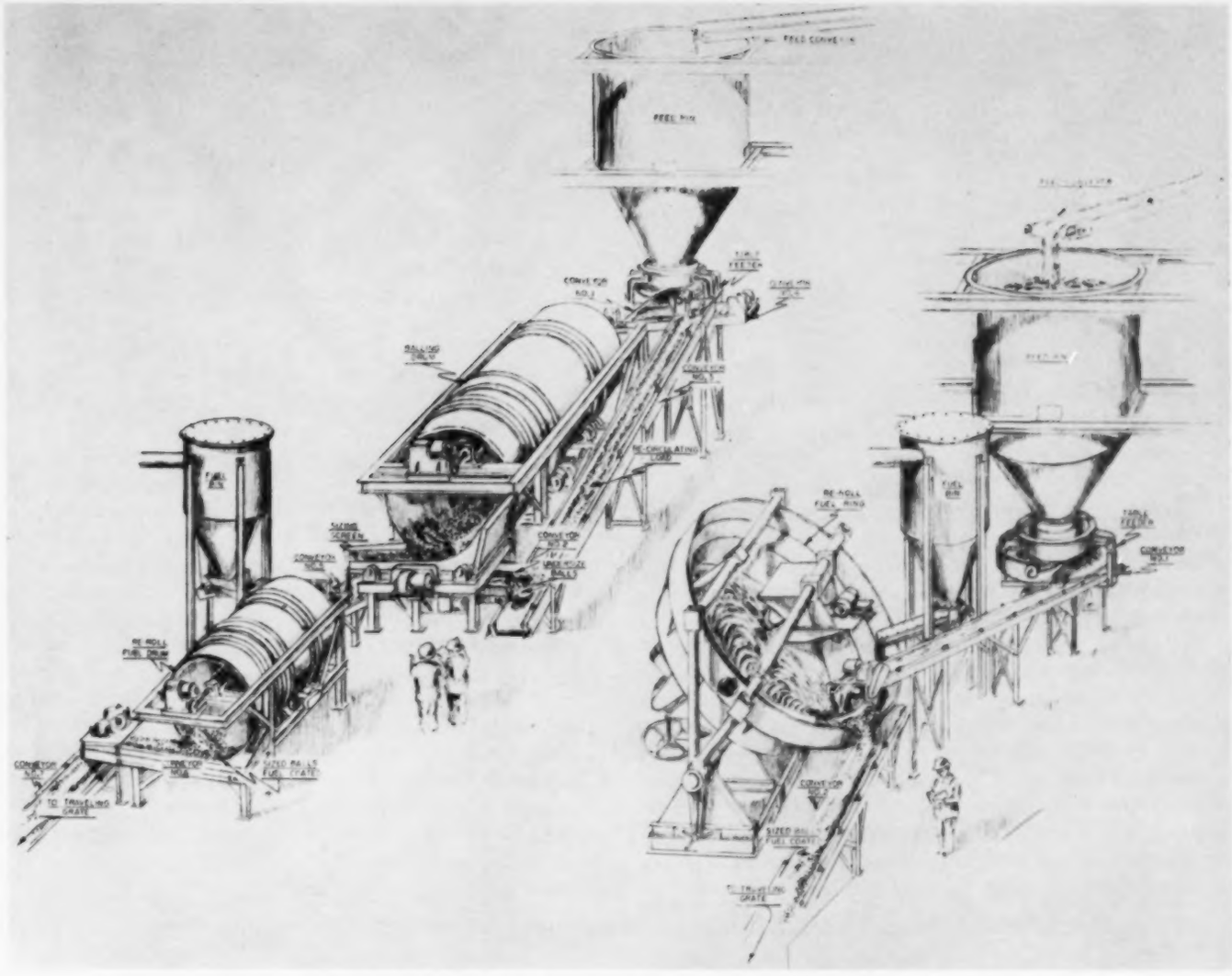


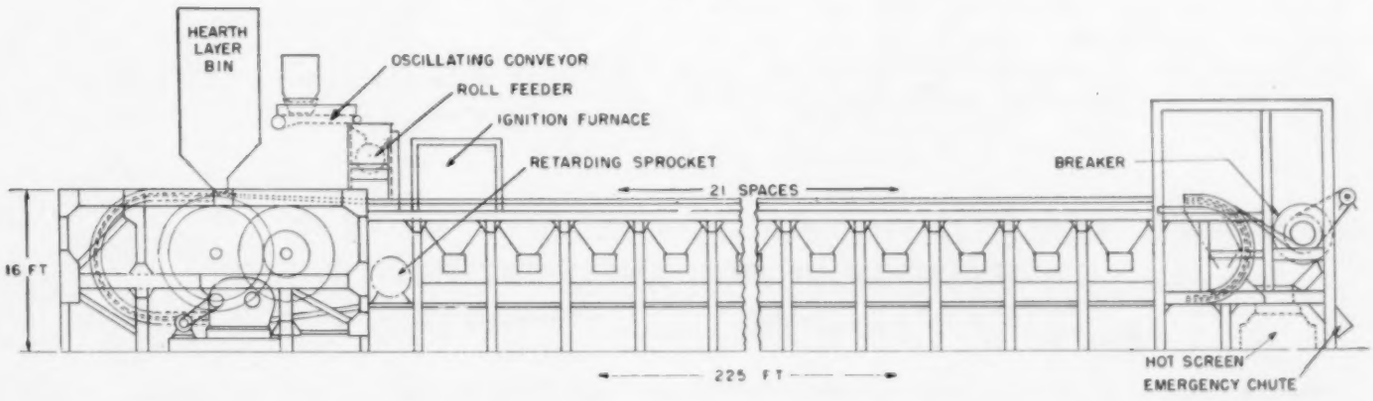
**Figure 23 — Sketch compares two types of balling circuits.**

sized pellets, including oversized pellets (about which little can be done) are delivered by means of another conveyor to the reroll drum in which the pellets are rolled in coal and thus prepared for firing on the sintering machine.

With the "flying saucer" the material is delivered from the table feeder directly into the pan. As it is discharged from the saucer, the material drops into a reroll ring on the outer rim of the saucer. Coal is added to the rim and the discharged pellets are rolled in the fuel exactly as they were in the reroll drum of the first setup. They are then discharged to the conveyor and transferred to the sintering machine for burning. This arrangement offers more uniform product, increased structural strength, lower initial cost, and lower horsepower and maintenance.

A modern design of a sintering machine is illustrated in Figure 24. The use of a hearth-layer has some inherent advantages, one of which is elimination of sinter keying to the grate bars. Without a hearth layer, impact

**Figure 24 — One of the latest sintering machines constructed is this shown for the Ohio Works of the United States Steel Corp.**



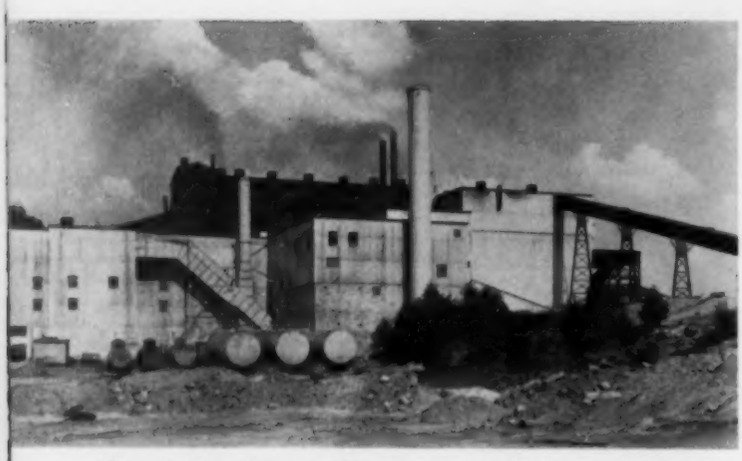


**Figure 25 — Newer sintering plant design is more compact, built lower to the ground and has eliminated much of the smoke.**

at the end of a machine is necessary to dislodge the sinter cake. This impact causes considerable wear and necessitates heavy structural design capable of withstanding severe shock.

With the retarding sprocket, the pallet bump is eliminated without inclusion of the old return sprocket, which develops almost as much impact as the fire-fall design and causes considerable wear on the pallet wheels or hubs, depending on which is engaged. The retarder is held by an eddy-current clutch and works against the force developed by the head of pallets moving around the discharge curve. As the machine continues to drive, this force is overcome and a pallet drives the sprocket until the point of disengagement is reached. The pallet then rides the sloped incline to the engagement point of the drive-sprocket teeth.

Then the pallets rotate freely around the discharge end without the gap which causes fall-through into the collector chutes and without impact.

Figure 25 shows in the foreground a completed modern sintering plant while in the background is an earlier installation. In the earlier plants, it seems to have been traditional that the machine be located high up in the building, resulting in increased cubic footage and required steel tonnage. Sinter was discharged down steep chutes, resulting in severe breakage and wear. The concept of today's plant is a more compact, clean lined building, with the machine down just as low as good design will permit and with sinter discharge as short as possible.

The new plant is in operation in Figure 25, although it is hard to tell it from the stack discharge, while it is quite obvious from the stacks that the earlier plant is in operation. Here again is something new in sintering—the consciousness of cleanliness, an atmosphere in which housekeeping is emphasized. Maintenance is thereby reduced, resulting in efficient operation.

We believe that the day of the single expert who sells the job, supervises the design and starts the plant is truly gone. Instead, we have team work between specialists whose accomplishments can keep ahead of what is accepted as today's ultimate. Thus, we can be prepared for future use of controlled atmospheres; updraft or combinations of up-and-downdraft firing, or perhaps even cross draft firing; beds of perhaps three feet or more in depth; and many other possibilities now under study.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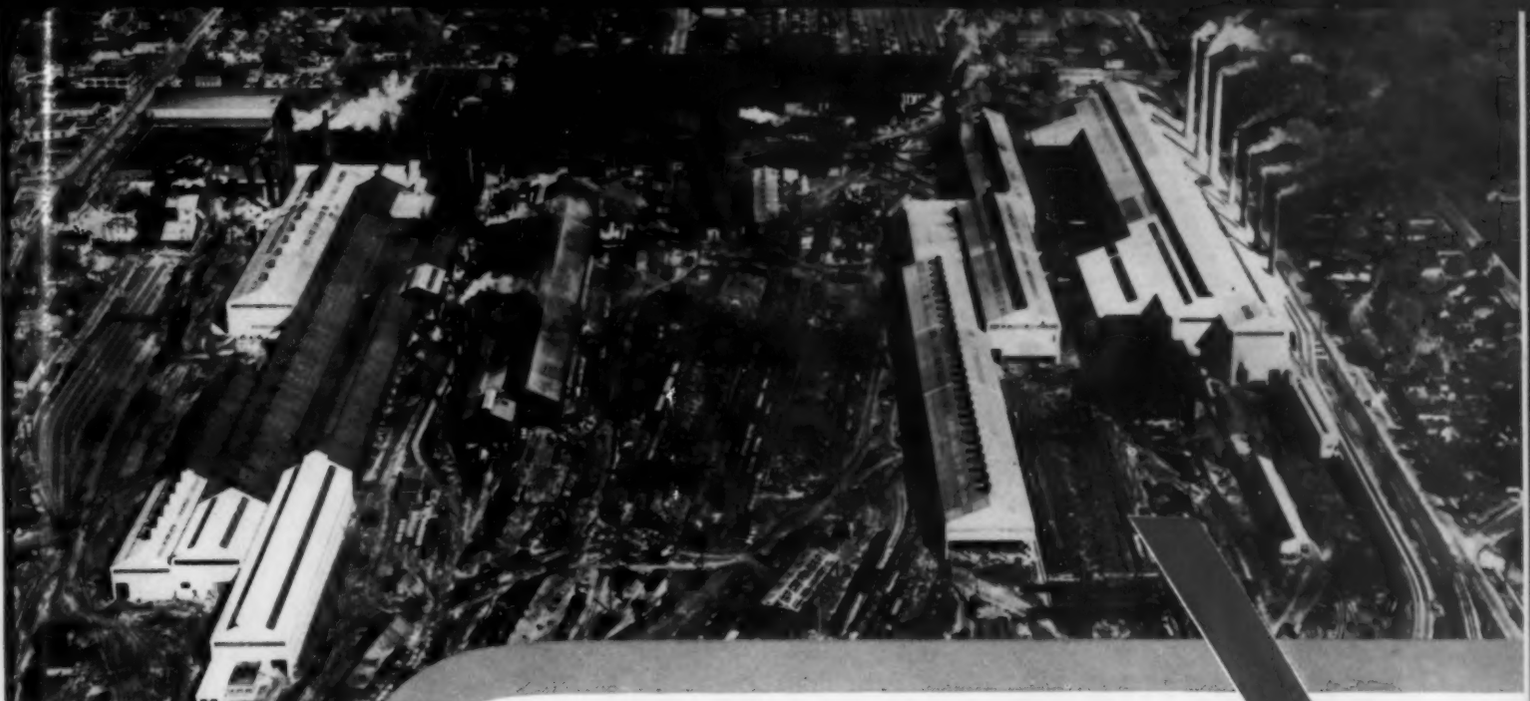

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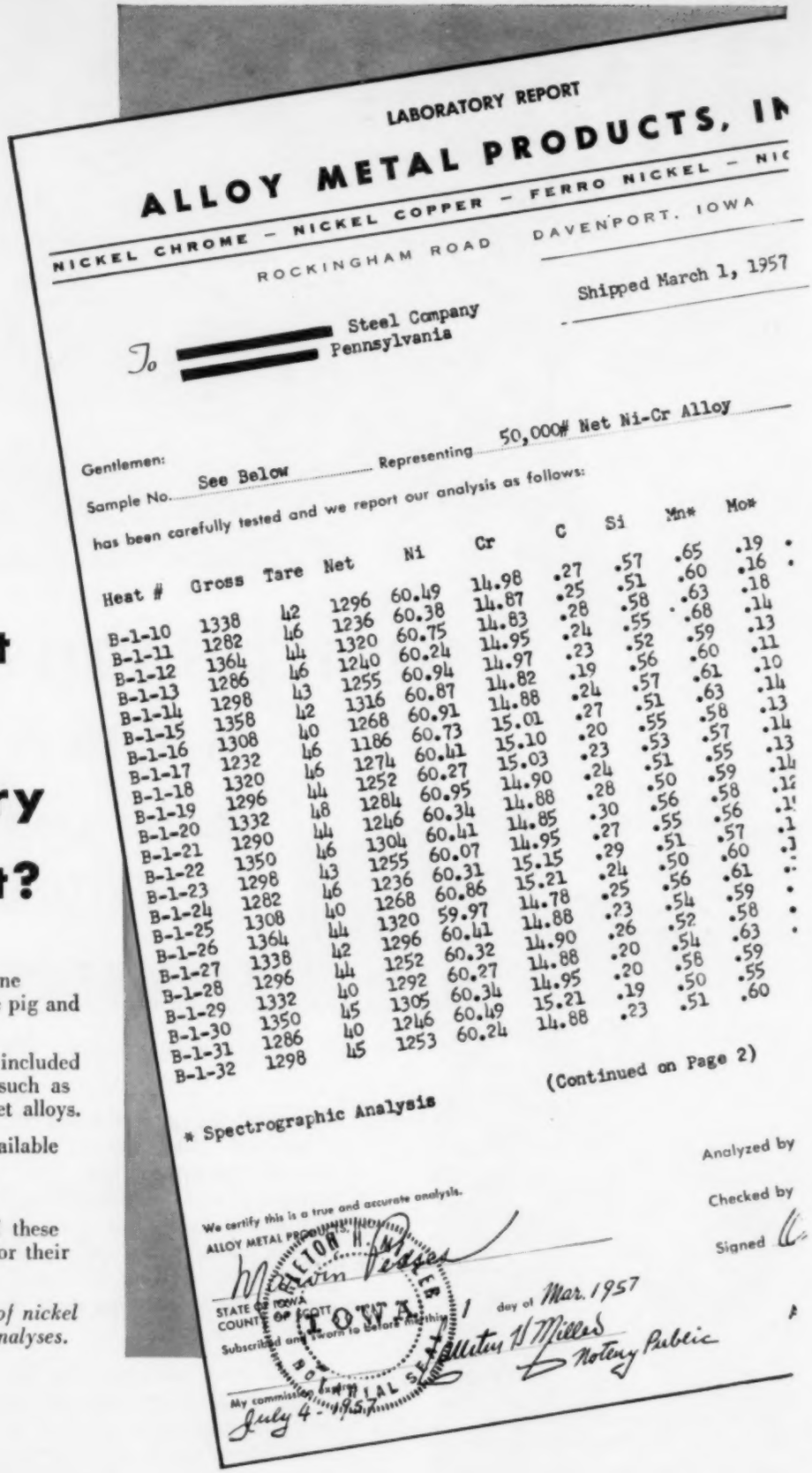

LABORATORY REPORT

ALLOY METAL PRODUCTS, IN

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Shipped March 1, 1957

To [redacted] Steel Company
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has been carefully tested and we report our analysis as follows:

| Heat # | Gross | Tare | Net | Ni | Cr | C | Si | Mn* | Mo* | |
|---|---|---|---|---|---|---|---|---|---|---|
| B-1-10 | 1338 | 42 | 1296 | 60.49 | 14.98 | .27 | .57 | .65 | .19 | . |
| B-1-11 | 1282 | 46 | 1236 | 60.38 | 14.87 | .25 | .51 | .60 | .16 | . |
| B-1-12 | 1364 | 44 | 1320 | 60.75 | 14.83 | .28 | .58 | .63 | .18 | |
| B-1-13 | 1286 | 46 | 1240 | 60.24 | 14.95 | .24 | .55 | .68 | .14 | |
| B-1-14 | 1298 | 43 | 1255 | 60.94 | 14.97 | .23 | .52 | .59 | .13 | |
| B-1-15 | 1358 | 42 | 1316 | 60.87 | 14.82 | .19 | .56 | .60 | .11 | |
| B-1-16 | 1308 | 40 | 1268 | 60.91 | 14.88 | .24 | .57 | .61 | .10 | |
| B-1-17 | 1232 | 46 | 1186 | 60.73 | 15.01 | .27 | .51 | .63 | .14 | |
| B-1-18 | 1320 | 46 | 1274 | 60.41 | 15.10 | .20 | .55 | .58 | .13 | |
| B-1-19 | 1296 | 44 | 1252 | 60.27 | 15.03 | .23 | .53 | .57 | .14 | |
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| B-1-21 | 1290 | 44 | 1246 | 60.34 | 14.88 | .28 | .50 | .59 | .14 | |
| B-1-22 | 1350 | 46 | 1304 | 60.41 | 14.85 | .30 | .56 | .58 | .12 | |
| B-1-23 | 1298 | 43 | 1255 | 60.07 | 14.95 | .27 | .55 | .56 | .1 | |
| B-1-24 | 1282 | 46 | 1236 | 60.31 | 15.15 | .29 | .51 | .57 | .1 | |
| B-1-25 | 1308 | 40 | 1268 | 60.86 | 15.21 | .24 | .50 | .60 | .1 | |
| B-1-26 | 1364 | 44 | 1320 | 59.97 | 14.78 | .25 | .56 | .61 | . | |
| B-1-27 | 1338 | 42 | 1296 | 60.41 | 14.88 | .23 | .54 | .59 | . | |
| B-1-28 | 1296 | 44 | 1252 | 60.32 | 14.90 | .26 | .52 | .58 | . | |
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| B-1-30 | 1350 | 45 | 1305 | 60.34 | 14.95 | .20 | .58 | .59 | | |
| B-1-31 | 1286 | 40 | 1246 | 60.49 | 15.21 | .19 | .50 | .55 | | |
| B-1-32 | 1298 | 45 | 1253 | 60.24 | 14.88 | .23 | .51 | .60 | | |

(Continued on Page 2)

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# E. W. Bliss Company Reaches Century Mark

▲ THE E. W. Bliss Co., of Canton, Ohio, celebrates its 100th anniversary of service to the metalworking industry this year. From its modest start as a builder of presses in 1857, the company has grown, by corporate acquisition and progressive engineering, to become an all-around supplier of metalworking machinery. It is a leading builder of presses . . . it is a major supplier of rolling mills and, through its Mackintosh-Hemphill Division, it produces rolls, lathes, tube straighteners and cinder pots . . . it builds a variety of can making machinery . . . it manufactures die sets, and sells a complete line of die supplies . . . its Special Products Division produces all types of military and non-military items. There are now six separate divisions and 11 plants in five states, a Canadian subsidiary and overseas operations in England and France, as well as two U.S. subsidiaries.

The Press Division, father of all the rest, produces mechanical and hydraulic presses that serve every industry that uses metal as a raw material. Of all types and sizes, these presses range from small, high-speed units for delicate electronic grids and plates to massive giants which can shape an aluminum ingot into an aircraft part with one mighty squeeze.

The history of the E. W. Bliss Co. in the rolling mill field goes back over 35 years, when it began principally as a specialty shop, concentrating on special mills and accessories for ferrous and non-ferrous plants—on small orders and jobs so specialized that not many others were willing to tackle them.

This naturally led to concentration on the development of mill accessories such as tension reels, levellers, coilers, edgers, trimmers, shears, etc., and resulted in many engineering "firsts."

Bliss was among the pioneers in aluminum foil mills and also in cluster mills in the United States. It produced the first expanding mandrel-type hot down-coiler. It designed the first tension and payoff reels which could handle 75,000-lb cold coils. It built and installed; for Jones & Laughlin, the fastest tin temper mill in the world, a two-stand mill which turns out 42-in. tin plate at speeds in excess of 75 mphr. It supplied the first large aluminum trimmer.

With these achievements, Bliss grew, both in engineering and manufacturing facilities and in industry-wide prestige. While it still handles special jobs, it has also built complete continuous hot strip mills for some of the nation's biggest producers.

Recently Bliss bought controlling interest in Matteson Equipment Co., designers of special continuous strip annealing lines, continuous pickling lines, hot dip equipment and other steel mill equipment. It also purchased an interest in the Chemetals Corp., which holds patents on a process of producing metal strips from powders of metal. The Rolling Mill Division has developed the machines which make this production possible.

In 1955 Bliss took its greatest single step in increasing its rolling mill facilities when it purchased Mackintosh-Hemphill Co., a manufacturer of metalworking rolls and other mill equipment since 1803. This is now a separate Bliss division devoted to the manufacture of metalworking rolls, electronic

**Figure 1 — This Bliss tandem cold mill has four stands 19 in. and 51 in. x 52 in., and is installed at Empire Steel Co., Mansfield, Ohio. It can roll strip in coils weighing up to 34,000 lb at speeds up to 1866 fpm.**

heavy-duty contouring lathes, rotary tube straighteners, special alloy castings and cinder pots.

Bliss has produced automatic and semi-automatic can making machinery and other special equipment since the late 1800's. Among the Can Machinery Division's most recent developments is a new line of high-speed machines, including the new Bliss strip feed press, which can turn out 600 finished can tops every minute, and the new bodymaker, which produces 450 can bodies per minute.

Die Supply became a Bliss division in 1954. Known as Dieco, it manufactures die sets, including standard sets and special sets to customer specifications, and markets, as a distributor, a complete line of die makers' supplies.

In its Special Products Division, Bliss has handled important government contracts for almost a century, calling for shells for all types of guns, aircraft catapults, machine guns, and atomic energy and jet engine components. This division also builds all types of special machinery for private contractors, such as tube reducing machines, water wheels, filter presses and ore boat engine housings, to name just a few.

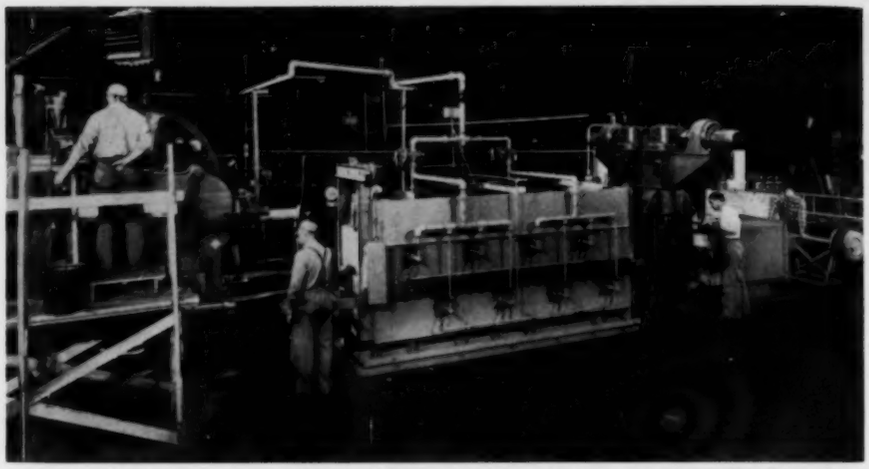

**Figure 2 — This powder metal sintering pilot line is operating at E. W. Bliss Co.'s Salem plant. Under this process, metal strip, tubing and other products can be fabricated directly from powder, without first melting the powder into cakes or ingots. Savings are said to run about 80 per cent over conventional rolling costs. The process can be applied to copper, nickel, titanium and other metals. Metal powder feeds from the hopper at top left through compacting rolls, and is then passed through a sintering furnace and the hot mill rolls. The finished strip compares favorably with fine strip rolled by conventional multi-cycle rolling techniques.**

Bliss has also handled a number of "turnkey" jobs, the most recent being at the Cleveland Division of Jones & Laughlin Steel Corp. There Bliss is acting as the contracting engineer for the entire $18,000,000 job—foundations, the plant itself, mills and auxiliaries.

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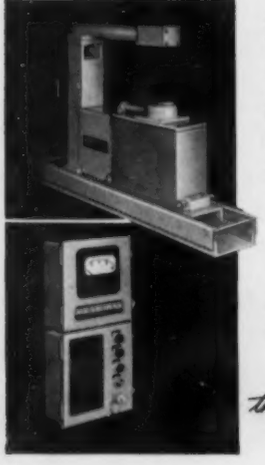

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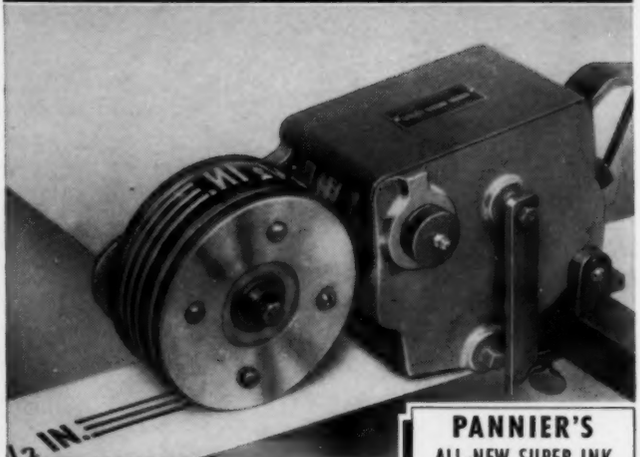

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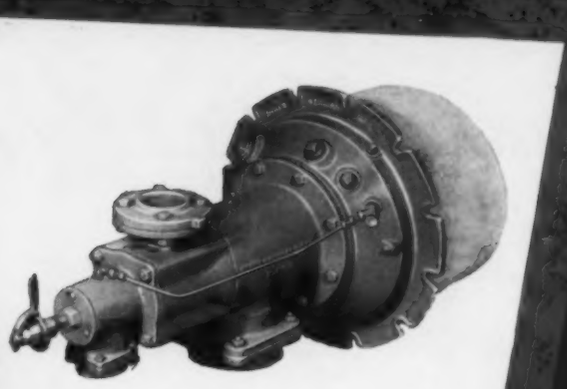

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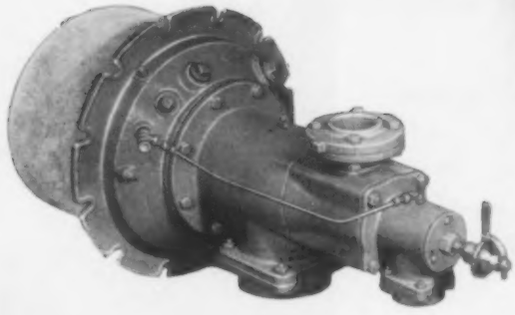

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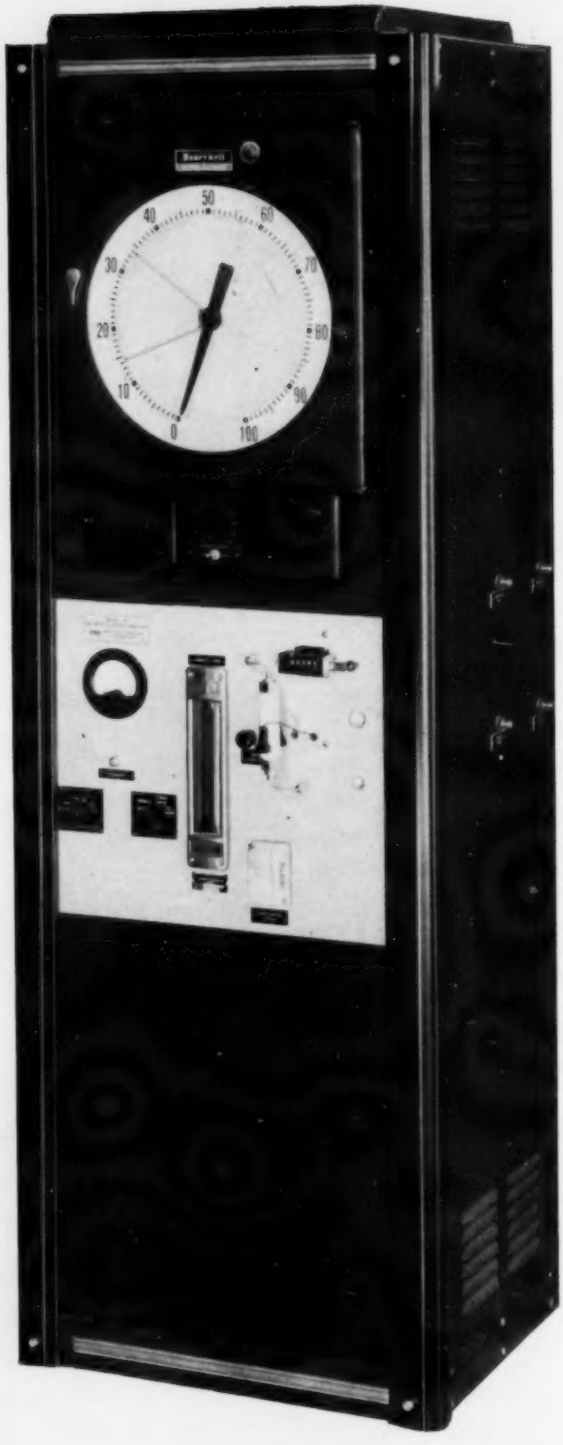

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**Figure 1 — A unique jacking method enabled Eichleay Corp. to raise this 200-ton crown atop the stands (left) of a transfer press without endangering nearby production stations at the McKeesport, Pa., plant of Kelsey-Hayes Co.**

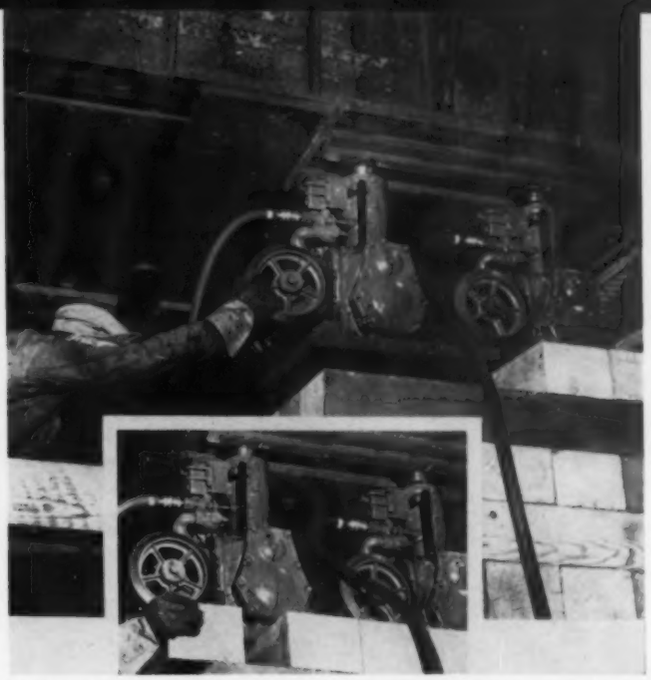


**Figure 2 — Two 100-ton air motor screw jacks were placed under each corner of the crown. One set of four jacks (one under each corner) was raised and the other set blocked (inset). Less than 10 hr were required to jack the crown 17 ft.**

# Jacks Reduce Machinery Erection Time

▲ INDUSTRY'S trend toward bigger automated machinery has brought with it a new problem—how to install equipment in confined areas without tying up or endangering nearby production stations.

Eichleay Corp. faced the same problem when it installed a 200-ton crown assembly atop a 3000-ton capacity transfer press in the McKeesport, Pa., plant of Kelsey-Hayes Co. The Pittsburgh industrial contracting firm devised a method which not only did not interfere with production, but also was safer and cut one-third off installation time.

Eichleay had to lift the heavy crown, which is 10 ft high and wide and 22 ft long, almost 17 ft from the plant floor and lower it on top of the press stands. Normal contracting practice calls for use of a gantry and rigging in similar situations, but the method could not be employed at Kelsey-Hayes.

The gantry was ruled out as too hazardous for the job. Nearby conveyors and production stations would have been endangered every time a beam or frame was hoisted.

The unique method developed by Eichleay engineers was built around the use of eight 100-ton air motor screw jacks designed by Duff-Norton Co. of Pittsburgh.

Two jacks were positioned under each corner of the 200-ton crown. Four of the jacks—one under each corner—were raised simultaneously about 14 in. and the other set of four was blocked. The two units were alternately raised and blocked until the crown was eight in. above the 16-ft height of the stands.

A winch was used to pull the crown and falsework—moving on rollers—into place. Then the crown was lowered onto the stands and the falsework removed.

The entire job took five days, although the actual jacking required less than 10 hr. If a gantry had been used, seven days would have been needed to complete the installation.

The jacking method, is also safer than the gantry. Rigging is only as safe as each of its individual cables and if one cable breaks, the entire rigging collapses.

The Duff-Norton jacks are mechanical screw jacks, and once locked in place will not creep under load. When the full limit of the raise is reached, an automatic shutoff device stops the air motor. A safety key way in the ram prevents the head from turning and shifting the load.

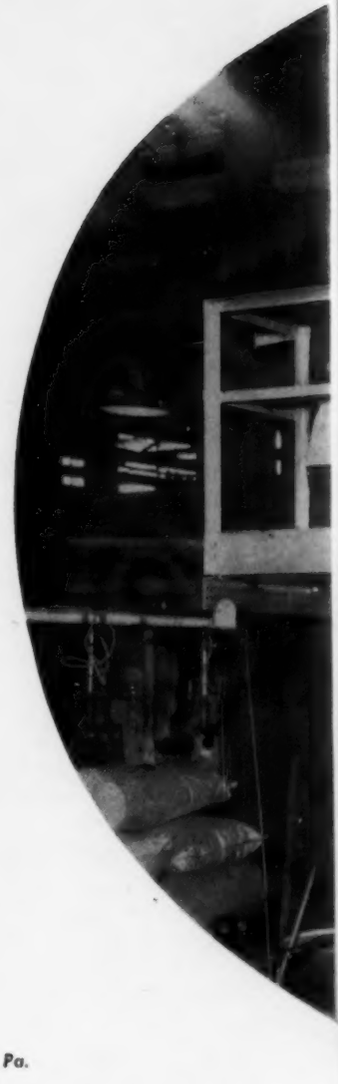
The jacks require only normal air pressure of 80 to 90 psi to raise capacity loads. Eichleay used a receiver tank from the Kelsey-Hayes plant line with 100-psi pressure.

By using the jacks, Eichleay and Kelsey-Hayes also were spared another headache. The crown is tied down to the stand by four 9-ton rods (or bolts) that are 14 in. in diameter and 38 ft long. If the gantry method had been employed, part of the plant roof would have had to be removed and the rods lowered through the crown and stands.

Instead, the rods were sunk through the plant floor into the basement. The stands were erected and then the rods were pulled up through the holes in the stands and crown after the latter was positioned

Eichleay completed the installation of the crown without mishap or interrupting production.

# "Our Turbo Air Blowers were often shutdown by motor starting currents . . . *until we changed to Fusetron Fuses*"



"As our Turbo air blowers build up speed there is a back up pressure exerted which puts an overload on the motors. Consequently, it takes longer for the motors to gain normal running speed.

"Frequently, the 100 ampere renewable fuses we were using couldn't hold these overloads—and we would have a shutdown.

"We were anxious to eliminate these down-periods, but we didn't want to sacrifice safe fuse protection on our 30 h. p., 3600 R. P. M., 220 volt, 3 phase, 60 cycle motors that power the Turbo air blowers.

"We decided to protect these motors with 100 ampere Fusetron dual-element fuses. This move proved to be the answer to our problem. Since changing to Fusetron fuses we haven't had any trouble with our Turbo air blowers being 'knocked out' on motor starting currents."

*B. D. McGaughey*
ELECTRICAL SUPERINTENDENT,
*Copperweld Steel Company, Glassport, Pa.*

## HERE'S HOW FUSETRON FUSES PROTECT AGAINST NEEDLESS BLOWS CAUSED BY HARMLESS OVERLOADS.

Fusetron dual-element fuses will hold motor-starting currents or other harmless overloads without opening because they have a tremendous time-lag.

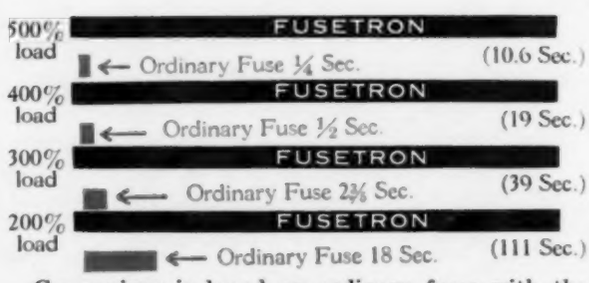
A machine may momentarily stall or be overloaded and Fusetron fuses won't open.

A motor may be started under heavy load—or all the motors on a circuit may be started at once—and Fusetron fuses won't open.

Circuits can be loaded nearer to the capacity of panelboards and switches without having Fusetron fuses open needlessly.

**Here's a comparison of time-lag between Fusetron and ordinary fuses**

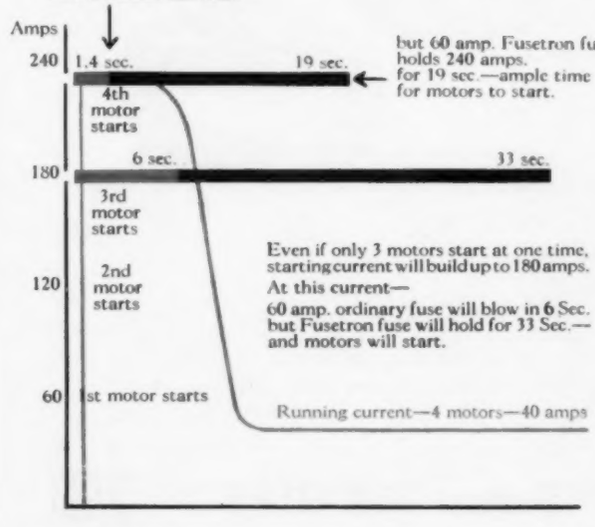
Notice that even at 500% load a Fusetron fuse will hold on for more than 10 seconds—while an ordinary fuse will open in less than ¼ second. Yet, with all this time-lag, there is no sacrifice of safety.




Comparison is based on ordinary fuses with the longest time-lag. Figures apply to 30 amp. 250 volt size. Opening time on larger sizes and on 600 volt sizes is longer.

**Here's an example of how Fusetron fuse time-lag works**

For example: take four 10 amp. motors on a circuit. 60 amp. ordinary fuses would be used to protect the circuit. BUT see what happens when four motors start at one time. The starting current of each motor is about 60 amps. so the combined starting currents would reach 240 amps.


At this load—
60 amp. ordinary fuse blows in 1-4/10 Sec. before motors can start—
Amps
240
1.4 sec.
19 sec.
but 60 amp. Fusetron fuse holds 240 amps. for 19 sec.—ample time for motors to start.
4th motor starts
6 sec.
33 sec.
180
3rd motor starts
Even if only 3 motors start at one time, starting current will build up to 180 amps.
At this current—
60 amp. ordinary fuse will blow in 6 Sec. but Fusetron fuse will hold for 33 Sec.—and motors will start.
120
2nd motor starts
60
1st motor starts
Running current—4 motors—40 amps

So with Fusetron fuses installed in Mains, Feeders and all Branch circuits—shutdowns caused by needless blowing of fuses are ENTIRELY WIPED OUT.

**Don't risk losses!** One needless shutdown . . . one lost motor . . . one destroyed switch or panel . . . one burned out solenoid . . . may cost you far more than replacing every ordinary fuse with Fusetron dual-element fuses. Write for bulletin FIS.

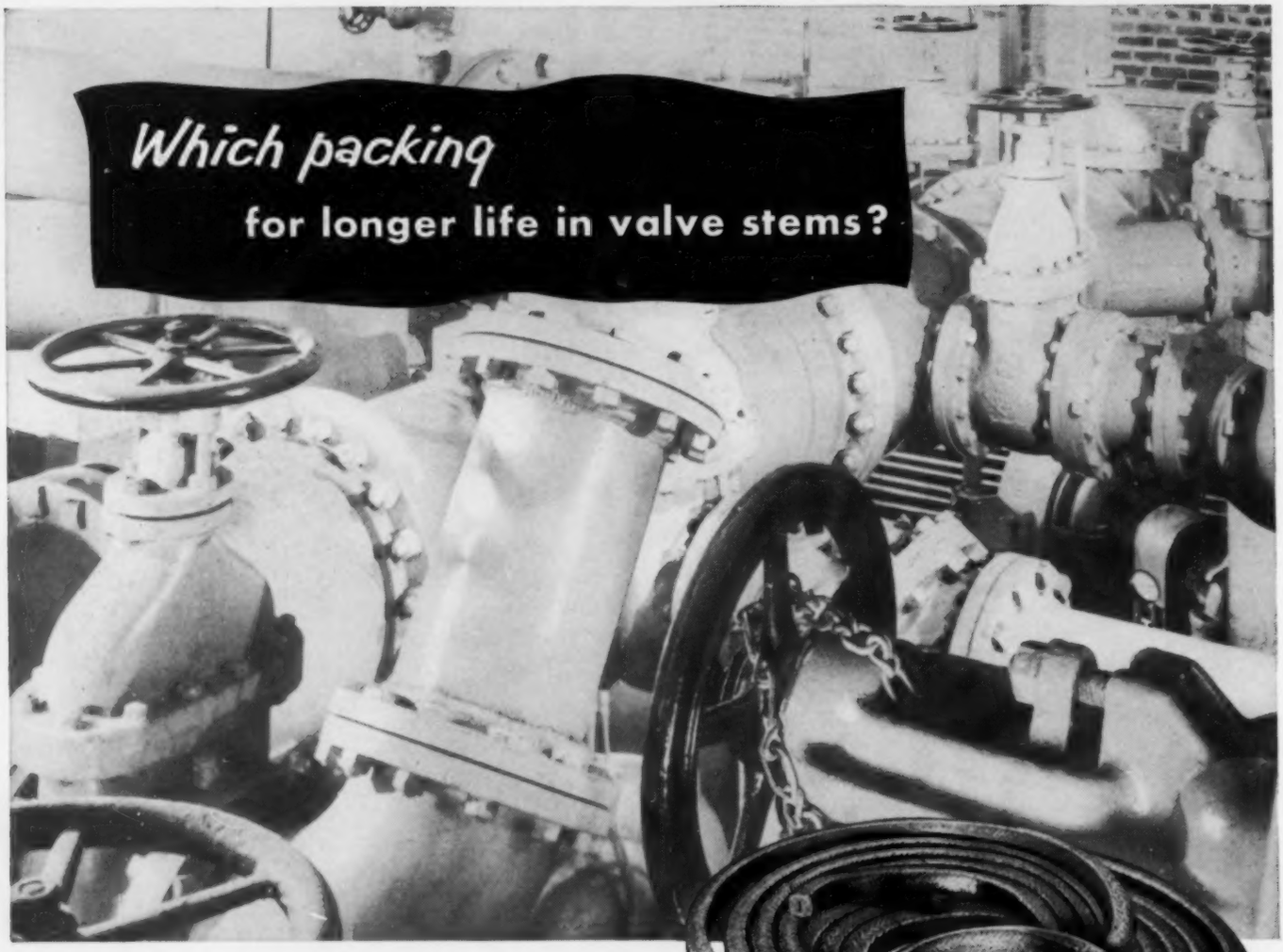
**For loads above 600 amps.— Use BUSS Hi-Cap Fuses to coordinate your electrical circuits.**

On 600 volts or less, BUSS Hi-Cap fuses have an interrupting capacity sufficient to handle any fault current regardless of system growth.

They can be coordinated with Fusetron fuses on feeder and branch circuits to limit fault outages to circuits of origin. Write for bulletin HCS.

**Bussmann Mfg. Division** (McGraw-Edison Co.)
University at Jefferson, St. Louis 7, Mo.

***Play safe!*** *install Fusetron dual-element fuses and BUSS Hi-Cap Fuses throughout entire Electrical System!*




**. . . for heavy fluids, steam, water and gas . . .**
***it's J-M Jewett®***

Strong, tough Jewett has been proven the ideal packing for heavy duty valve stem service against crude and heavy oils, tar, molasses and other heavy gummy fluids. It also provides efficient sealing against steam; fresh or salt, hot or cold water; air; gas and some chemicals requiring a packing free from rubber.

The basis of Jewett's exceptional durability is its construction of high-quality long fibre asbestos yarn with fine copper wire inserts. This yarn is braided over a lead ribbon core and formed square. Style 10 is treated with a heavy bodied, heat-resisting lubricant which won't bleed in valve stem service. Furnished graphited in coil or ring form in sizes from ⅛″ up.

**. . . for superheated steam and gases to 1200F**
***it's J-M High Temperature***

When valves are operating in high temperature service, your best packing choice is Johns-Manville High Temperature Style 397. It retains its resilience, holds a tight, lasting seal against superheated steam and dry gases under elevated pressures and temperatures up to 1200F.

To obtain this high sealing efficiency, Johns-Manville braids asbestos yarn of high purity over a plastic core of special heat resistant composition. For extra strength, the yarn is reinforced with tough heat and corrosion resistant Inconel wire. The packing is formed square and then lubricated with graphite. Furnished in ring, coil and spiral form in sizes ¼″ to 1″.

**Your local J-M distributor** carries full stocks of Jewett, High Temperature and other packings. Call him today or write Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

**Johns-Manville PACKINGS, GASKETS and TEXTILES**

# ALLEGHENY LUDLUM PUTS LARGE VACUUM FURNACE INTO OPERATION

▲ ALLEGHENY Ludlum Steel Corporation has placed in operation at Watervliet, N. Y., what is believed to be the world's largest furnace for melting high-purity super-alloys under vacuum. The new furnace, using the consumable electrode remelting process pioneered by Allegheny Ludlum, is capable of producing 26-in.-diam ingots, weighing up to 12,000 lb—believed to be the heaviest ingots ever produced by any vacuum melting process. Previously, the largest ingots of super-alloys made by the consumable electrode process were 20 in. in diameter and weighed about 5000 lb.

Commercial availability of 26-in. ingots, which the new furnace makes possible, will enable the super-alloys such as A-286 to be used in many commercial applications which were previously not feasible because of restricted ingot size.

In a number of applications, such as large gas turbine wheels, high ductility and fatigue strength are required, particularly at the center of the wheel. Ductility depends upon cleanliness and freedom from segregation in the large billet sections from which such wheels are forged. Because of melting under vacuum and other unique characteristics of the consumable electrode furnace, ingots of extreme cleanliness and virtual freedom from segregation are produced.

In addition to high-alloy steels, the consumable electrode process is also used in melting zirconium, titanium and a wide range of ferrous and nonferrous alloys. The metals so melted are remarkably free of impurities and have superior qualities of performance.

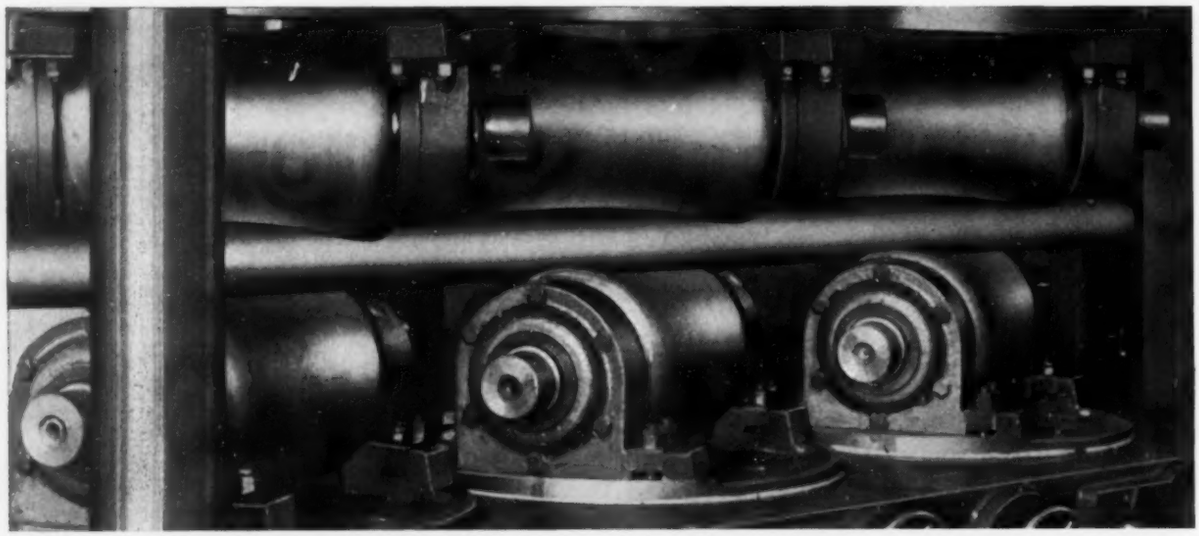
Allegheny Ludlum first began commercial melting of super-alloys by the consumable electrode process in October, 1955, with the start-up of a new department at Watervliet capable of producing 250,000 lb of the metals a month. The new furnace, completing the third round of expansion of the process, brings Allegheny Ludlum's capacity for producing the supermetals to 2,000,000 ingot lb monthly.

**Figure 1 — Workmen at the Watervliet Works guide a copper crucible into the company's new consumable electrode vacuum melting furnace. The crucible serves as the mold for an ingot of super-alloy. The new furnace is capable of producing 26-in. diam ingots, weighing up to 12,000 lb.**

# TIPS FROM A ROLL MAKER'S NOTEBOOK

**MACKINTOSH-HEMPHILL DIVISION, E. W. BLISS COMPANY, Pittsburgh 3, Pennsylvania**

Cast mill rolls • Johnston cinder pots • rotary tube straighteners • end-thrust bearings • heavy-duty lathes • steel and special alloy castings



Line contact of rolls and tubing is shown clearly in this photograph of a tube length passing through the rolls of a Mack-Hemp rotary tube straightener.

## Odd twists on roll wear in rotary tube straighteners

The production straightening of pipe and tube by passing it between concave cross rolls is quite unique in the demands it places on the rolls. For example, slippage – the bane of most rolling operations – is a necessity in a rotary tube straightener. Without slippage, the straightened tube will show spiral markings.

**An unattainable goal**—Another unusual characteristic of this service is that when properly set, the rolls should wear evenly over their entire work surfaces. This is because the tubing makes a line contact with the roll surface. Thus, under ideal conditions, straightener rolls would operate continuously to worn-out diameter without any redressing at all.

Unfortunately, it is impossible to achieve this ideal. Any given straightener is usually designed to be used with a range of tube diameters. Hence, roll curvature must be for average diameter, a compromise.

**First rolls used were "overspecified"**—Mack-Hemp engineers have made a very thorough study of straightener rolls—Mack-Hemp itself builds a type of rotary tube straightener. At first, we believed that hard forged steel roll rings on forged steel shafts would be necessary for neck strength and wear resistance, but soon learned that cast steel rings gave longer life. As time went on, we used integral cast steel rolls for economy. Then cast iron rings on forged steel shafts proved best for wear and finally we found solid cast iron rolls to be sufficiently strong and most economical.

**Solid grain iron rolls best**—Today, we use cast-to-shape low-alloy grain iron rolls in the larger straighteners we build, and recommend their use in most other rotary tube straighteners. (In small straighteners, hardened steel rolls are still practical because of the relatively higher cost of small chilled castings). Mack-Hemp "Technigrain" rolls have ample strength for this service. Casting to shape provides a uniform depth of hardness over the entire surface, while the graphite in the iron has the "lubricant" quality needed for slippage without excessive wear.

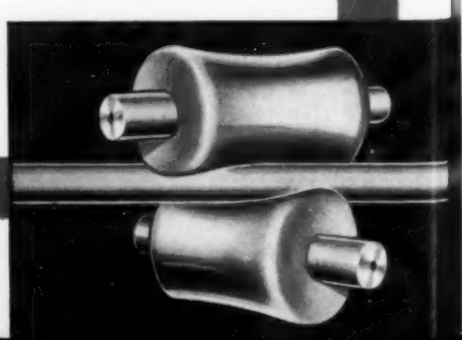
The history of tube straightener rolls shows how Mack-Hemp's broad experience in all phases of roll use can help you choose exactly the right roll. Feel free to call on us at any time . . . there's no obligation.

**MACKINTOSH-HEMPHILL**

*You get more tonnage from the rolls with the Striped Red Wabblers*

**Division of E. W. BLISS COMPANY**

**Presses, Rolling Mills, Special Machinery**



# Okonite Company Opens New Plant

▲ THE Okonite Co. formally opened its third New Jersey plant on June 19 at North Brunswick, N. J. The new plant, originally built by Studebaker for an automobile assembly operation, has undergone almost a year of redesign and remodeling by Okonite, to make it one of the most modern cable-producing facilities in existence.

Incorporated in the plant is most of the machinery from the company's former operation at Wilkes-Barre, Pa., plus some $2,000,000 worth of new machinery. The plant itself was purchased for $4,205,000 and covers an area of 160 acres. The building is 1400 ft long and 360 ft wide at its widest point.

The opening of this plant consolidates all of Okonite's manufacturing operations in New Jersey, enabling that state to take the lead in electric wire and cable manufacturing throughout the country.

The plant is designed to produce rubber and plastic-insulated wires and cables for power, control and communication purposes. It will add between 15 and 20 per cent to the company's over-all manufacturing facilities, when operating at full capacity. The plant is primarily designed for the manufacture of standard cables in standard lengths, but is also sufficiently flexible to handle job-shop operations when required. The plant will manufacture wires and cables primarily for the electric utility, railroad and industrial markets, and will also produce the company's complete line of portable cords and cables for industrial and mining uses.

**Figure 1 — The new 446,000 sq ft cable plant of The Okonite Co. is located on a 160-acre property in North Brunswick, N. J., at the point where the main line of the Pennsylvania Railroad crosses over U. S. Highway 1. Originally built for a Studebaker assembly operation, but never used for that purpose, the plant has been completely revamped to handle heavy processing and manufacturing.**

The unusual length of the plant makes it possible to swedge down long lengths of aluminum sheathed cable, and already, experimentally, lengths in excess of 1000 ft have been produced.

The present layout of the plant has been kept quite flexible, so that when later additions come, only moderate changes need to be made in production flow. The most critical and heavy equipment is in its permanent location for the long-range picture.

In the immediate future, it is forseen that the present group of 400 employees may grow to as many as 500. There is adequate land for any conceivable future expansion to meet the growing needs of the electrical industry. Present equipment is capable of handling between 50 and 100 per cent more people than are presently employed.

**The overwhelming majority of cranes and pulpits being equipped with air conditioning are Lintern equipped.**

The reasons for this are contained in new, 20-page Bulletin AC-573 which describes Aire-Rectifiers for each temperature range of cab, also models for pulpits.

*Write for copy today.*

Larco, inc.

DISTRIBUTOR OF LINTERN CORPORATION PRODUCTS

ROUTE 20, EAST • PAINESVILLE, OHIO

**NOW—ALLOY CHAIN REPAIR SERVICE**

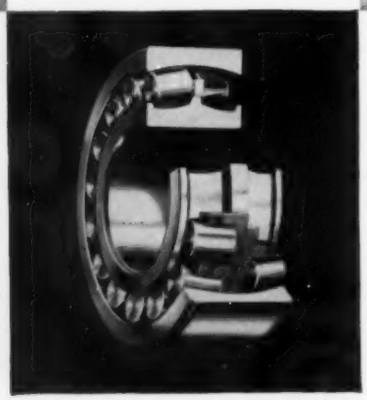
in PITTSBURGH and HAMMOND

For greater safety and economy, have your Alloy Sling Chains returned to either our Pittsburgh or Hammond plant for repair, inspection and testing, at nominal cost.

S. G. TAYLOR CHAIN CO., Hammond, Ind. and 3505 Smallman St., Pittsburgh 1, Pa.

**TORRINGTON SPHERICAL ROLLER BEARINGS GIVE YOU THESE FEATURES**

- inherent self-alignment
- conformity of rollers to races
- positive roller guidance
- land-riding bronze cages
- integral flange for stability
- maximum radial and thrust capacity
- long, smooth service life
- even load distribution



# Mated perfectly ~ for life!

Make a point to notice the roller end and center guide flange in a Torrington Spherical Roller Bearing. The perfect mating there means a smoother, longer bearing life.

Roller end and flange surfaces alike are ground to a common spherical radius centered on the common vertex of bearing axis and roller axis. Under all load conditions, the rollers bear lightly but constantly against this flange. This guides the roller positively with minimum friction and prevents skewing. Stress concentrations leading to early failure are avoided, so the bearing will serve you many good turns longer.

This is the kind of feature Torrington builds into its bearings out of its experience with all major types serving in all kinds of equipment. Care for such details is matched only by our care in mating the *right* bearing to the *right* job. In this, your Torrington representative is an expert: call on him when you need help. *The Torrington Company*, South Bend 21, Ind.—Torrington, Conn.

**TORRINGTON BEARINGS**

*District Offices and Distributors in Principal Cities of United States and Canada*

**SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST**

electronically-
controlled

# ELLIOTT

## motors and generators provide fully-automatic operation in this NEW, MODERN ROD MILL

Hot Copper billets in this new and modern rod mill speed through two 3-high roughing mill stands and seven continuous finishing mill stands to three coilers in a fully-automatic operation. A finished coil of $\frac{5}{16}$-in or $\frac{7}{16}$-in wire is delivered every 19 seconds.

The entire mill is powered by Elliott motors and generators, electronically-controlled. The utilization of an adjustable-voltage system results in a flexible control and consequently, a flexible mill.

The two roughing stands are driven by Elliott squirrel-cage motors, a 300-hp, 720-rpm and a 450-hp, 720-rpm. Finishing stands are driven by an Elliott 200-hp, 690/825-rpm d-c motor and several Elliott 350-hp, 500/1250-rpm motors. The three coilers are driven by Elliott 20-hp motors.

Various other Elliott motors, exciter sets and the Elliott 1000-kw, 600-volt adjustable voltage motor-generator set which supports the main drive d-c motors, are not shown in the picture. Here is another example of Elliott engineering keeping pace with the latest technological advances.

W7-8

**ELLIOTT Company**

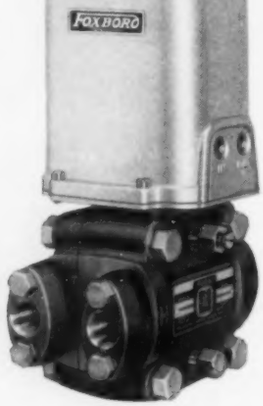
*Crocker-Wheeler Division* • **Jeannette, Penna.**

# GET THE BEST SOLUTION TO EVERY FLOW

## . . . with Foxboro instrumentation

### Differential Pressure Cell Transmitters

Complete line includes air-operated and electric-operated d/p Cell Transmitters covering ranges from 0-20" to 0-800" of water; working pressures up to 1500 psi.




### Type 13A d/p Cell Transmitter

- Positive Overrange Protection—up to full 1500 lb. rating
- Fully Adjustable Ranges—0-20" to 0-250" water
- Automatic Internal Damping — fast, stable measurement
- Simplicity—easiest, lowest-cost installation, lowest maintenance

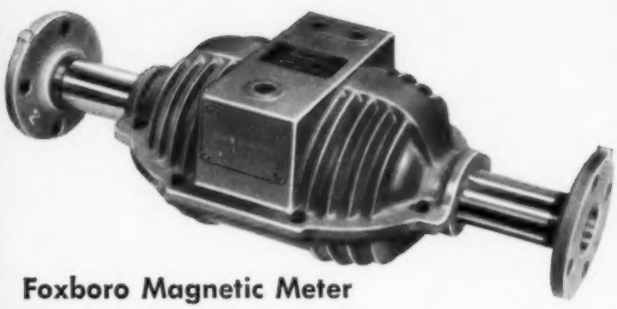
### Mercury Type Meters

Complete line includes mercury types covering ranges from 2 to 400" of water; working pressures up to 5000 psi.

### Type 28 Mercury Meter

- Permanent Full-Scale Meter Accuracy — exclusive segmental lever design provides linear transmission from float to pen
- Highest-Powered Pen Drive — large float with long travel
- Minimum Ambient Temperature Effects — float located in high pressure chamber

# PROBLEM



## Foxboro Magnetic Meter

- Measures Fluid Velocity Directly
- Adds No Pressure Drop
- Uniform Flow Scale
- Overall Accuracy Better than 1% of Range Over Entire Scale
- Full Accuracy Sustained Even on Liquids Other Meters Can't Handle — even sand and water slurries

THERE ARE two logical reasons why Foxboro Instrumentation assures you *optimum* results in measurement or control of process fluid streams. First; Foxboro offers the widest variety of measuring and controlling devices . . . the *right* equipment for every application. For example, only Foxboro offers all these basic meter types: differential pressure cell flow transmitters, magnetic meters, mercury meters, and weir meters. Second; Foxboro provides 45 years of engineering experience in every phase of fluid mechanics. From the simplest general utility-type instrument to complex automatic ratio control systems, you get highest accuracy, efficiency, and economy. Whenever you have a flow problem involving liquids, vapors, gases, or slurries — in pipes, ducts, or channels, you can solve it best by specifying Foxboro. Only a few instruments are described on these pages. For full details; or for specific information on *your* problem, contact your nearby Foxboro Field Engineer, or write **The Foxboro Company, 587 Neponset Ave., Foxboro, Mass.**

FOXBORO

REG. U. S. PAT. OFF.

***FIRST* IN FLOW**

*FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND*

## Float-and-Cable Type Meters

- Rigid Construction — weather-tight case; all working parts of corrosion-resistant materials
- Powerful Accurate Operation — large, high-stability float; stainless steel cable — non-stretching, non-twisting
- Direct Reading Chart and Scale
- Direct Reading Integral Counter

## Other Foxboro Flow Instrumentation

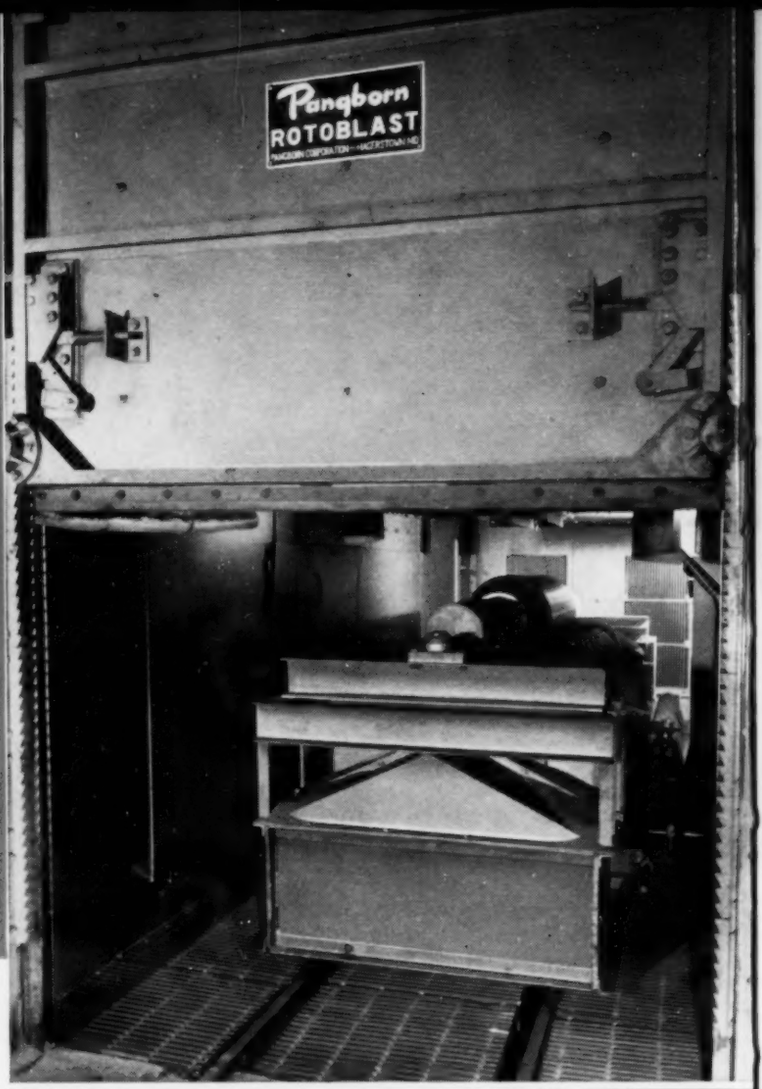
Electric or Pneumatic Type Rotameters

Electric, Pneumatic, and Mechanical Integrators

Planimeters

All Primary Elements, Valves, and Accessories required for assembly of complete flow measurement and control systems

# Mill rolls etched twice as fast with Pangborn Rotoblast®



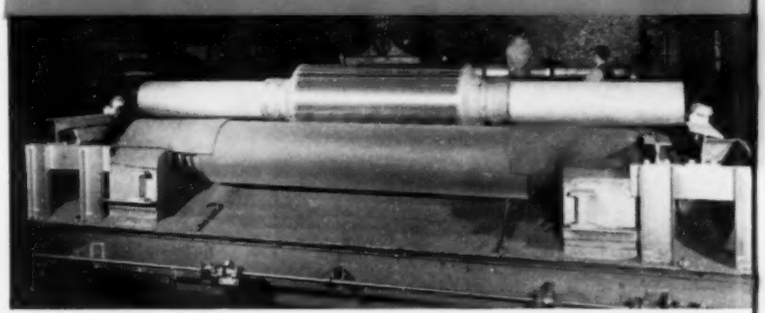

Faster and better . . . that's Pangborn's story for a leading steel producer. A year ago this mill replaced two air blast rooms—used for etching sheet machine rolls—with two Pangborn Rotoblast Roll Etching Machines.

According to management, these Pangborn Machines work *twice as fast* as the original equipment and do a much more uniform etching job. They are completely automatic and need no attention during operation. Furthermore, despite rough treatment 24 hours a day for the past year, these machines have required a minimum of maintenance.

This installation represents another case where Pangborn Rotoblast solved an individual problem. If you have an unusual blast application, Pangborn offers a special service. Pangborn engineers will study your problem and its relation to your production line. Then they will design a machine for your particular needs. Find out how Pangborn's engineering service can give you better cleaning and faster production at lower cost.

Write today for Bulletin 1210A to PANGBORN CORP., 4400 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

**BEFORE ROLL ETCHING**



**AFTER ROLL ETCHING**

**Pangborn blast cleans cheaper**

# P&H Electronic "Stepless" Control

## The greatest crane advance in a decade!

P&H has taken a giant step forward in improving crane operation and reducing crane maintenance by introducing P&H Electronic "Stepless" Control. Not since Magnetorque — another P&H first — has crane design been so improved.

With P&H Electronic Control, material movement is much faster, smoother; even tremendous loads are precisely spotted without jerky "inching" motion.

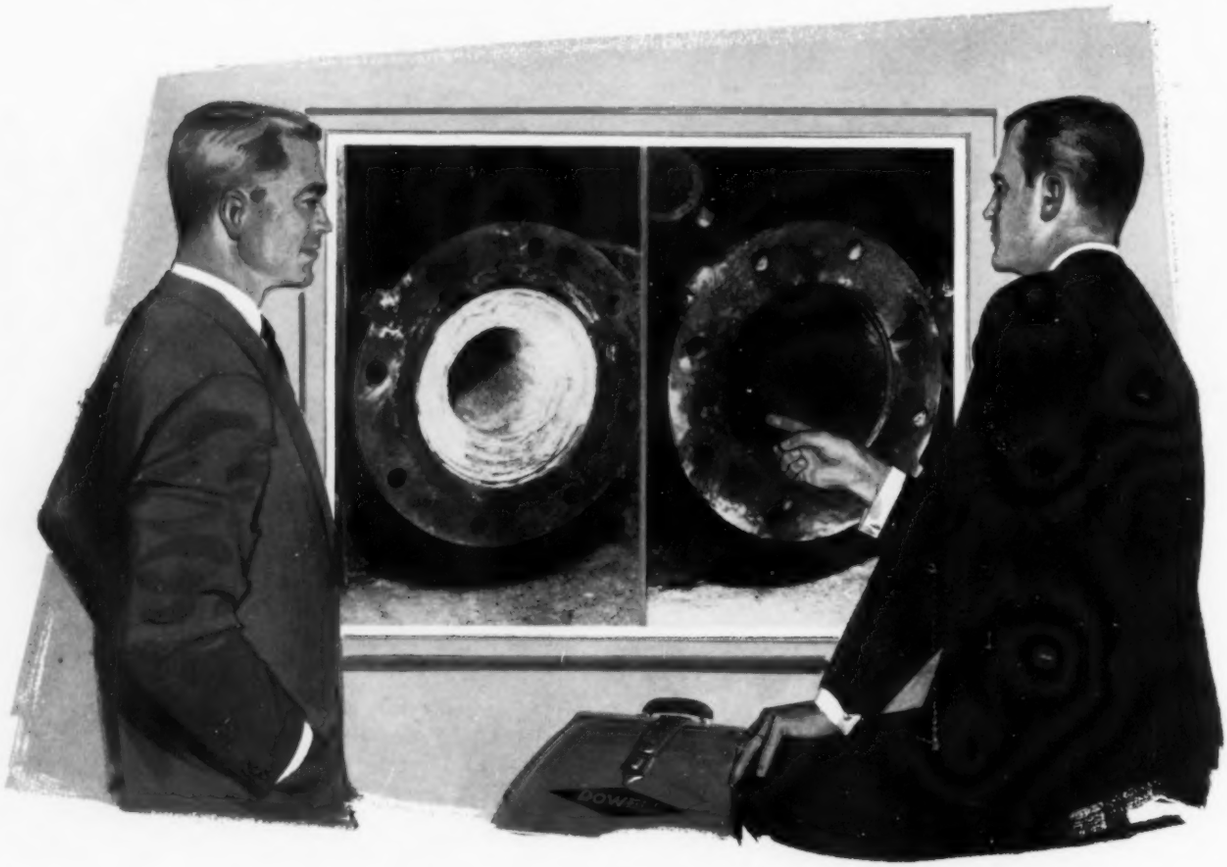
The new control eliminates considerable maintenance, too. It has a simple wiring circuit which replaces 29 sets of contacts — the most frequently replaced parts on other controls. The same Electronic Control panel serves all size cranes — reduces your protective parts inventory to low levels.

For complete information on this revolutionary crane control, write for pamphlet "P&H Electronic Stepless Control" to Dept. 124G, Harnischfeger Corp., Milwaukee 46, Wisconsin.

**HARNISCHFEGER**

P&H ...quality and service for 73 years

# *here's how Dowell chemical cleaning saved $71,000 and helped protect a plant profit!*



A few months before their peak season, the operators of this plant decided their main water line might not supply the water necessary to meet peak demands. The line was cast-iron, 16-inches in diameter and over 7,000 feet long. Its original flow efficiency or "C" factor had been 105; scale build-up had reduced this to 72. To lay an auxiliary line would cost at least $85,000.

Dowell contracted to clean the pipe chemically for a little less than $14,000, and to restore a minimum of 50 per cent of the line's lost capacity.

This Dowell did, and more—increasing the "C" factor to 92! Enough water was immediately available for capacity operation. This saved the plant $71,000 and helped protect the company's annual profit.

The operating credit realized by this food processing plant, as a result of Dowell service, is similar to those realized by other Dowell customers—in the steel, paper, chemical, oil refining, power and allied industries.

Dowell engineers are experts in the use of solvents to remove scale and sludge—deposits that cut the throughput of product, process and steam generating systems. Dowell does the job, furnishing all chemicals, trained personnel, pumping and control equipment.

For specific information on how chemical cleaning can help you to greater profits, call the Dowell office nearest you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

*Have Dowell clean it chemically* **DOWELL**

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

# Date-line Diary...

**July 1**

▲ The AISI reports that the operating rate of the steel industry for the week of July 1 is scheduled at 79.1 per cent of capacity. This is equivalent to 2,024,000 tons compared with 2,150,000 tons one week ago and 302,000 tons one year ago. Index of production for the week is 126.0.

▲ The Aluminum Assn. reports shipments of aluminum sheet and plate in May, 1957 equaled 126,899,000 lb, compared with 116,709,000 lb in April, 1957; shipments of aluminum foil in May, 1957 amounted to 13,845,888 lb compared with 14,501,076 lb in April, 1957.

**July 2**

▲ Auto production in June totaled 500,271 cars, off 5.9 per cent from May, but 15.3 per cent above June, 1956. Assemblies for the first half of 1957 amounted to 3,372,850 cars, 5.6 per cent above the same period in 1956.

▲ Zinc prices declined ½¢ to 10¢ per lb in East St. Louis; spot copper, in London, receded to 26.96¢ a lb; domestic prices for custom smelter copper fell to 28½¢ a lb, down ½¢.

**July 3**

▲ The Federal Reserve Board reported that consumer installment debt in May, 1957 rose $369,000,000 to total $31,900,000,000; an increase of $2,100,000,000 over the May, 1956 total.

▲ The Bureau of Mines reported that the consumption of scrap during April, 1957 totaled 5,821,000 gross tons and pig iron 5,858,000 gross tons compared with 6,294,038 gross tons of scrap and 6,155,334 tons of pig iron in March, 1957.

**July 5**

▲ McLouth Steel Corp. filed a registration statement with the SEC covering a proposed public sale of 105,000 shares of its cumulative convertible preferred stock, of par value $100. Net proceeds of this sale will be used to provide a portion of the funds needed for the corporation's proposed $34,000,000 1957–58 expansion program.

**July 8**

▲ Prime Minister Diefenbaker disclosed that Canada plans to switch 15 per cent of its United States imports to Great Britain. In return, Britain is expected to help assure open markets for Canadian farm products in Western Europe.

▲ The AISI reports that the operating rate of the steel industry for the week of July 8 is scheduled at 80.4 per cent of capacity. This is equivalent to 2,057,000 tons compared with 2,009,000 tons one week ago and 317,000 tons one year ago. Index of production for the week is 128.1.

**July 9**

▲ Kaiser Steel Corp. placed $40,000,000 of first mortgage bonds, due 1977, and $5,000,000 in 25-year convertible promissory notes privately to partly finance an additional $81,000,000 additional expansion fund to be used mainly to double the capacity of the Fontana plant.

▲ The General Services Administration rejected International Nickel's proposal that the U. S. government agree to buy part of its expanded nickel output, explaining that nickel expansion now in progress promises to make 440,000,000 lb yearly available by 1961 compared with 300,000,000 lb now.

▲ The AISI reported that the iron and steel industry's estimated payroll for May, 1957 was $338,000,000, compared with $331,520,000 for April, 1957 and $333,570,000 in May, 1956. Average hourly payroll cost of wage earners in May was $2.824 (plus $0.29 for fringes) against $2.837 in April and $2.619 in May, 1956. Total employment was estimated at 666,400 during May, against 668,200 during April; average hours worked during May, 1957 equaled 37.9 compared with 38.0 in April, 1957, and 40.1 in May, 1956.

**July 10**

▲ Pig iron producers in southern U. S. raised price $3.50 a ton citing higher labor rates and increased cost of materials and freight as responsible for the increase.

▲ The American Iron Ore Assn. reported that loadings of ore into vessels at northern Lake Superior ports last week totaled 3,207,421 gross tons, compared with shipments of 1,580,739 gross tons in the same period of 1956.

▲ The AISC reports that shipments of heavy structural shapes for 1956 totaled 5,349,000 net tons, and plates 7,715,000 net tons. Estimated shipments in 1957 are 6,600,000 net tons of heavy structural shapes, 9,400,000 net tons of plates.

**July 12**

▲ The Commerce Dept. reported that the nation's total output of goods and services in 1956 totaled $414,700,000,000. It was previously estimated at $412,400,000,000. National income rose to $343,600,000,000 in 1956, and it was previously estimated at $342,700,000,000. Gross national product, on a seasonally adjusted annual rate, is estimated at $429,100,000,000 for 1957; national income on this basis is estimated at $355,100,000,000 for 1957.

▲ Shipments of iron and steel castings during March, 1957 amounted to 1,371,213 short tons compared with ,1336,078 short tons in February, 1957 and 1,512,391 short tons in March, 1956; shipments in April, 1957 equaled 1,363,118 short tons compared with 1,365,028 in April, 1956.

▲ The AISI reports that shipments of finished steel products during May were 6,972,091 net tons, compared with 7,349,752 tons during April, 1957 and 7,764,776 tons during May, 1956.

**July 15**

▲ General Electric Co. reports sales for the first half of 1957 were $2,121,310,000 compared with sales of $1,958,974,000 for the same period of 1956; earnings for this period in 1957 amounted to $127,823,000 and in 1956 were $112,864,000; equivalent to $1.47 per share in 1957 and $1.30 in 1956.

▲ Spot copper in London declined ½¢ to 27¢ a lb.

▲ The AISI reports that the operating rate of the steel industry for the week of July 15 is scheduled at 81.0 per cent of capacity. This is equivalent to 2,073,000 tons compared with 2,015,000 tons one week ago and 377,000 tons one year ago. Index of production for the week is 129.0.

**July 16**

▲ Eastern Stainless Steel Corp. announced that arrangements have been made for an additional $5,000,000 loan to aid in financing its anticipated future increase in production and sales.

**July 17**

▲ Budget Director Brundage told House Democrats the administration presently plans government outlays in fiscal 1958 will be held to $70,800,000,000 which is $1,000,000,000 lower than the expenditures visualized for the current fiscal year by President Eisenhower last January.

▲ The Labor Department reported that private house starts in June dropped to a seasonal adjusted annual rate of 970,000 units which is compared with a yearly gait of 980,000 units in May, 1957 and 1,091,000 in June, 1956. In the first half of 1957 work was begun on 506,800 private and public dwellings, 13 per cent below the 1956 level.

▲ The Agricultural Department estimated farm income for the first six months in 1957 at 2½ per cent over the figure of $12,100,000,000 for same period in 1956.

▲ ARCI reports that deliveries of new domestic freight cars in June, 1957 totaled 8,377 compared with 8,824 in May and 5,550 cars in June, 1956. Orders totaled 4,918 cars in June, 1957 compared with 3,423 in May, 1957 and 2,859 in June, 1956. Backlog of cars on order as of July 1, 1957 stood at 91,810 cars.

▲ The American Iron Ore Assn. reported that shipments of iron ore down the Great Lakes last week totaled 3,385,426 gross tons, highest in four years.

**July 18**

▲ Northern producers of pig iron raised prices $1.50 a ton. This is in addition to the $2 increase made last March.

▲ Cold Metal Products Co. shareholders ratified the transfer of its assets and business to J & L Steel Corp. Shareholders will receive 69.25 per cent of one share of J & L common stock for each share of Cold Metal stock held. The company's operation will become the Strip Steel Div. of J & L.

**July 19**

▲ Resistance Welders Mfrs. Assn. reports shipments by members during June, 1957 exceeded $2,500,000, and report a backlog of nearly $11,000,000 on June 30, 1957; shipments by members for the first half, 1957 are slightly below shipments during the same period of 1956.

▲ The Commerce Dept. reported personal income rose to an annual pace of $343,800,000,000 in June, topping the May rate by $900,000,000, and $17,000,000,000 above the same period in 1956.

**July 22**

▲ Prices of copper declined ¼¢ to 28¼¢ a lb by custom smelters.

▲ The AISI reports that the operating rate of the steel industry for the week of July 22 is scheduled at 81.2 per cent of capacity. This is equivalent to 2,079,000 tons compared with 2,030,000 tons one week ago and 419,000 tons one year ago. Index of production for the week is 129.4.

▲ The Aluminum Assn. reports primary aluminum production in the United States during June, 1957 was 138,657 tons compared with 144,789 tons in May, 1957 and 145,726 tons in June, 1956. Output for the first half of 1957 amounted to 823,969 tons, compared with 860,304 tons in the same period of 1956.

**July 23**

▲ Allis-Chalmers Mfg. Co. reported sales for the first half of 1957 amounted to $285,831,554 compared with $294,264,807 in 1956; net earnings in 1957 amounted to $11,292,018 equivalent to $1.35 a share; in 1956 earnings equaled $11,855,735 or $1.44 a share.

▲ The Council of Economic Advisers estimated that national production of goods and services rose to $433,500,000,000 yearly rate for the second quarter of 1957, an increase of $4,400,000,000 over the pace of the first quarter of 1957.

**July 25**

▲ The National Tool Builders Assn. reported that incoming business in June increased to $42,800,000 compared with $41,400,000 in May, 1957, but 31 per cent lower than June, 1956. For the first half of 1957, bookings were 38 per cent below the same period in 1956. The Association cited the loss of Air Force business as the cause of the decline in orders.

▲ General Motors report sales for the second quarter of 1957 at $2,837,000,000 a $33,000,000 increase over 1956. Unit sales of cars and trucks declined to 1,000,614, or 75,000 units less than in 1956. Sales for the first half of 1957 rose to $5,900,000,000, net profit was equivalent to $1.71 a share compared with $1.80 last year.

▲ According to report by F. W. Dodge Corp., June, 1957 contracts for future construction in the U. S. totaled $3,243,486,000, a 10 per cent increase over June, 1956. Total construction contracts for the first six months of 1957 amounted to $16,958,005,000, five per cent higher than the first half of 1956.

**July 26**

▲ The Bureau of Statistics (Canada) reported pig iron output for the first half of 1957 totaled 1,923,073 tons, compared with 1,727,684 for the same period of 1956; steel ingot output was 2,613,096 tons in 1957, and 2,556,446 tons in 1956.

▲ The Bureau of Mines reports that the consumption of scrap during May, 1957 totaled 5,753,000 gross tons and pig iron 5,862,000 gross tons compared with 5,816,309 tons of scrap and 5,856,587 tons of pig iron in April.

▲ The AISC reports that shipments of fabricated structural steel for June, 1957 were 329,256 tons, compared with 329,626 tons in May, 1957 and 284,719 tons in June, 1956. Bookings for June, 1957 were 220,025 tons compared with 291,750 tons in May, 1957 and 337,230 tons in June, 1956; backlog on June 30 equaled 3,219,908 tons, approximately 13 per cent above a year ago.

**July 29**

▲ The AISI reports that the operating rate of the steel industry for the week of July 29 is scheduled at 82.2 per cent of capacity. This is equivalent to 2,103,000 tons compared with 2,033,000 tons one week ago and 415,000 tons one year ago. Index of production for the week is 130.9.

▲ Agreement has been reached between the AFL-CIO Cement Workers and Universal Atlas ending the five-week strike. The new contract provides wage-benefit increases estimated at 16.5¢ an hr and compromises key issues. The action is expected to set off a round of agreements that could restore peace to the industry.

▲ The Aluminum Company of America announced a 1¢ per lb increase in the price of basic aluminum pig, to 26¢ per lb effective August 1.

## STEEL COMPANIES QUARTERLY FINANCIAL REPORTS—ENDING JUNE 30, 1957

| | Period | 1957 Net Sales | 1957 Net profits | 1957 Earnings per share | 1956 Net sales | 1956 Net profits | 1956 Earnings per share |
|---|---|---|---|---|---|---|---|
| Acme Steel Co. | 2nd quar. | $ 38,415,142 | $ 1,707,322 | $0.69 | $ 32,282,958 | $ 2,008,053 | $ 1.01 |
| | 1st half | 82,629,081 | 3,941.773 | 1.62 | 64,065,961 | 3,814,167 | 1.93 |
| Alan Wood Steel Co. | 2nd quar. | 17,837,000 | 936,000 | 0.35 | 17,231,000 | 1,267,000 | 0.76 |
| Allegheny Ludlum Steel Corp. | 2nd quar. | 72,415,439 | 2,951,427 | 0.77 | 79,012,940 | 4,517,971 | 1.21 |
| | 1st half | 153,710,065 | 7,742,092 | 2.01 | 153,787,605 | 9,090,579 | 2.44 |
| Algoma Steel Corp., Ltd. | 2nd quar. | ..... | ..... | ... | ..... | ..... | ... |
| | 1st half | ..... | ..... | ... | ..... | ..... | ... |
| Armco Steel Corp. | 2nd quar. | 202,913,611 | 15,022,540 | 1.25 | 204,667,132 | 17,418,448 | 1.60 |
| | 1st half | 401,119,030 | 30,510,292 | 2.55 | 394,625,478 | 37,097,427 | 3.42 |
| Atlas Steels, Ltd. | 2nd quar. | ..... | 528,800 | 0.49 | ..... | 1,150,000 | 1.35 |
| | 1st half | ..... | 1,579,000 | 1.46 | ..... | 2,175,000 | 2.54 |
| Barium Steel Corp. | 1st half | 59,557,000 | 3,340,000 | 0.82 | 56,008,000 | 2,914,000 | ... |
| Bethlehem Steel Corp. | 2nd quar. | 687,226,813 | 50,273,507 | 1.09 | 670,353,986 | 50,298,227 | 1.09 |
| | 1st half | 1,363,334,801 | 103,701,162 | 2.25 | 1,269,910,142 | 95,262,014 | 2.07 |
| Colorado Fuel and Iron Corp. | 2nd quar. | ..... | 4,352,322 | 1.24 | ..... | 4,693,556 | 1.34 |
| | 1st half | 185,788,000 | 8,904,714 | 2.55 | 184,701,000 | 8,709,970 | 2.48 |
| Continental Steel Corp. | 2nd quar. | 13,294,271 | 1,024,048 | 2.04 | 13,873,891 | 861,761 | 1.72 |
| | 1st half | 24,416,230 | 1,686,310 | 3.36 | 26,368,956 | 1,590,404 | 3.17 |
| Copperweld Steel Co. | 1st half | 51,440,015 | 1,579,509 | 1.81 | 52,400,014 | 1,873,997 | 2.28 |
| Crucible Steel Co. of America | 2nd quar. | 65,705,550 | 2,673,390 | 0.73 | 76,416,044 | 4,405,828 | 1.21 |
| | 1st half | 136,304,345 | 6,045,996 | 1.66 | 145,666,831 | 8,086,794 | 2.22 |
| Carpenter Steel Co. | Year ending June 30 | ..... | 6,847,642 | 8.01 | ..... | 5,800,400 | 6.79 |
| Detroit Steel Corp. | 2nd quar. | 24,116,626 | 855,798 | 0.26 | 33,492,653 | 1,963,719 | 0.62 |
| | 1st half | 48,769,684 | 1,863,964 | 0.57 | 63,725,878 | 4,142,551 | 1.31 |
| Eastern Stainless Steel Corp. | 2nd quar. | 13,665,930 | 940,669 | 1.53 | 12,996,050 | ..... | 1.07 |
| | 1st half | 27,628,265 | 1,602,090 | 2.60 | 25,103,450 | 1,678,801 | 2.73 |
| Firth Sterling, Inc. | 2nd quar. | 8,826,200 | 414,400 | 0.31 | 7,556,600 | 289,400 | 0.26 |
| | 1st half | 17,336,700 | 812,400 | 0.61 | 13,191,300 | 508,000 | 0.45 |
| Granite City Steel Corp. | 2nd quar. | 32,292,379 | 2,857,505 | 1.33 | 35,616,136 | 3,829,021 | 1.79 |
| | 1st half | 65,988,260 | 6,261,956 | 2.92 | 71,573,214 | 7,672,822 | 3.58 |
| Inland Steel Co. | 2nd quar. | 203,131,202 | 15,150,752 | 2.68 | 201,968,419 | 14,944,932 | 2.70 |
| | 1st half | 406,780,842 | 29,764,456 | 5.26 | 392,348,707 | 28,960,481 | 5.23 |
| Interlake Iron Corp. | 1st half | 58,137,996 | 3,634,648 | 1.62 | 52,723,702 | 3,896,304 | 2.00 |
| Jessop Steel Co. | 2nd quar. | ..... | ..... | ... | ..... | ..... | ... |
| | 1st half | ..... | ..... | ... | ..... | ..... | ... |
| Jones & Laughlin Steel Corp. | 2nd quar. | 228,393,000 | 13,770,000 | 1.85 | 213,418,000 | 17,350,000 | 2.35 |
| | 1st half | 432,358,000 | 26,593,000 | 3.58 | 408,690,000 | 30,909,000 | 4.18 |
| Kaiser Steel Corp. | 1st half | 111,891,445 | 14,908,487 | 4.24 | 104,689,563 | 11,736,188 | 3.31 |
| Keystone Steel & Wire Co. | 2nd quar. | ..... | ..... | ... | ..... | ..... | ... |
| | 1st half | ..... | ..... | ... | ..... | ..... | ... |
| Laclede Steel Co. | 1st half | ..... | 1,865,514 | 9.04 | ..... | 2,161,531 | 10.48 |
| Lone Star Steel Co. | 1st half | ..... | 6,664,060 | 2.29 | ..... | 4,798,689 | 1.65 |
| Lukens Steel Co. | 24 wks. ending June 15 | 61,687,469 | 5,979,164 | 6.27 | 50,919,423 | 3,542,133 | 3.71 |
| McLouth Steel Corp. | 4 mos. Apr. 30 | 62,454,000 | 4,095,000 | 2.54 | 52,143,000 | 2,520,000 | 1.46 |
| National Steel Corp. | 2nd quar. | 166,490,249 | 12,607,341 | 1.70 | 177,033,747 | 14,858,824 | 2.01 |
| | 1st half | 343,348,458 | 26,108,847 | 2.01 | 347,639,665 | 28,961,410 | 3.92 |
| Pittsburgh Coke & Chemical Co. | 2nd quar. | ..... | ..... | ... | ..... | ..... | ... |
| | 1st half | ..... | ..... | ... | ..... | ..... | ... |
| Pittsburgh Steel Co. | 2nd quar. | 47,489,480 | 1,610,063 | 0.83 | 51,964,579 | 2,311,483 | 1.28 |
| | 1st half | 97,376,419 | 3,621,323 | 1.91 | 101,908,778 | 4,781,107 | 2.66 |
| Republic Steel Corp. | 2nd quar. | 338,249,637 | 24,865,071 | 1.60 | 351,454,168 | 26,491,060 | 1.71 |
| | 1st half | 692,655,830 | 52,917,897 | 3.40 | 684,052,643 | 51,532,452 | 3.33 |
| Rotary Electric Steel Co. | 2nd quar. | ..... | ..... | ... | ..... | ..... | ... |
| | 1st half | ..... | ..... | ... | ..... | ..... | ... |
| Sharon Steel Corp. | 2nd quar. | 37,829,217 | 1,137,381 | 1.03 | 50,531,426 | 2,067,761 | 1.88 |
| | 1st half | 85,495,006 | 2,730,025 | 2.48 | 100,678,987 | 4,325,632 | 3.93 |
| Superior Steel Corp. | 2nd quar. | ..... | ..... | ... | ..... | ..... | ... |
| | 1st half | ..... | ..... | ... | ..... | ..... | ... |
| United States Steel Corp. | 2nd quar. | 1,170,314,575 | 115,943,199 | 2.04 | 1,168,747,055 | 104,389,496 | 1.83 |
| | 1st half | 2,336,798,663 | 231,421,308 | 4.07 | 2,269,290,135 | 208,550,441 | 3.66 |
| Washington Steel Corp. | Quar. | ..... | 381,300 | 0.62 | ..... | 305,073 | 0.49 |
| | 9 mos. | ..... | 1,464,847 | 2.41 | ..... | 1,245,168 | 2.02 |
| Woodward Iron Co. | 2nd quar. | ..... | 2,003,228 | 0.95 | ..... | ..... | ... |
| | 1st half | ..... | 1,100,695 | 0.52 | ..... | 3,957,816 | 1.87 |
| Wheeling Steel Corp. | 2nd quar. | 67,994,000 | 2,834,000 | 1.24 | 76,213,000 | 6,119,000 | 2.93 |
| | 1st half | 139,338,000 | 7,393,000 | 3.36 | 144,068,000 | 11,399,000 | 5.43 |
| Youngstown Sheet and Tube Co. | 2nd quar. | 179,291,257 | 11,317,042 | 3.29 | 183,780,877 | 11,328,916 | 3.34 |
| | 1st half | 371,367,128 | 21,924,309 | 6.38 | 361,666,509 | 21,522,772 | 6.35 |

# HYDRAULIC INGOT STRIPPER

Patent Pending

*"Give us the Runway and we'll lift the World"*

• This 450-ton *hydraulic* ingot stripper is arranged for 360° revolving of the tongs to twist off the sprue of bottom poured ingots. Tongs are power operated and equipped with bits, so that in addition to stripping ingots, they also handle ingots, slabs or moulds for storage. Alliance engineers will work with you on any heavy materials handling problem. Consult them. They'll develop an efficient, economical solution for you.

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Tong's range:
To suit your moulds
and ingots

Stripping mould

# Alliance

Handling ingot

Handling ingot

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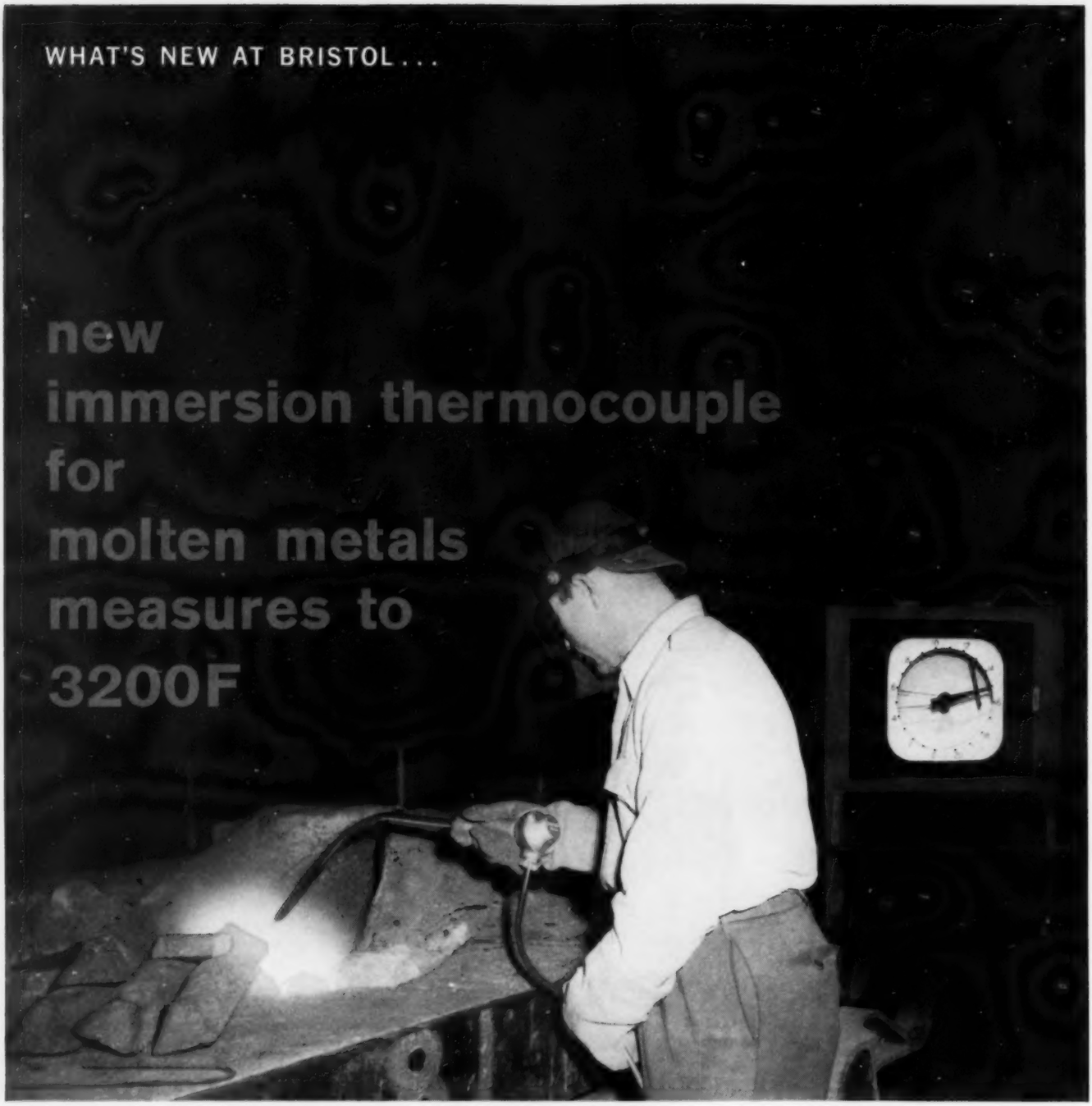


**NEW BRISTOL IMMERSION THERMOCOUPLE** makes direct readings in melts of ferrous or non-ferrous metals, records on round-chart Bristol Dynamaster instrument (right).

This new Bristol immersion-type thermocouple can take up to 14 dips in molten steel at 2700 F to 3200 F. With brass, aluminum and other metals of lower melting point, it has far longer life.

Simplicity, operating economy result from the new thermocouple's rugged, easily replaceable protection tubes. With reasonable care, they allow reuse of the expensive platinum sensing element.

This new Bristol immersion thermocouple is typical of recent outstanding Bristol developments in electronic pyrometry. Bristol's giant strides in automatic temperature control *are making instrument systems obsolete which were designed new only a few years ago.* Find out about these developments, before you buy any other instrument for furnace or oven. Write The Bristol Company, 123 Bristol Road, Waterbury 20, Conn. 7.23

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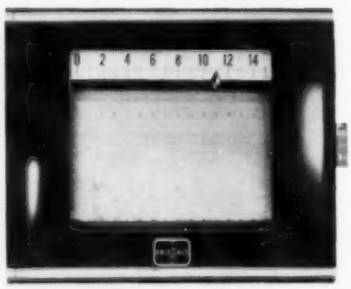



Dynamaster* Electronic Pyrometer with strip chart.

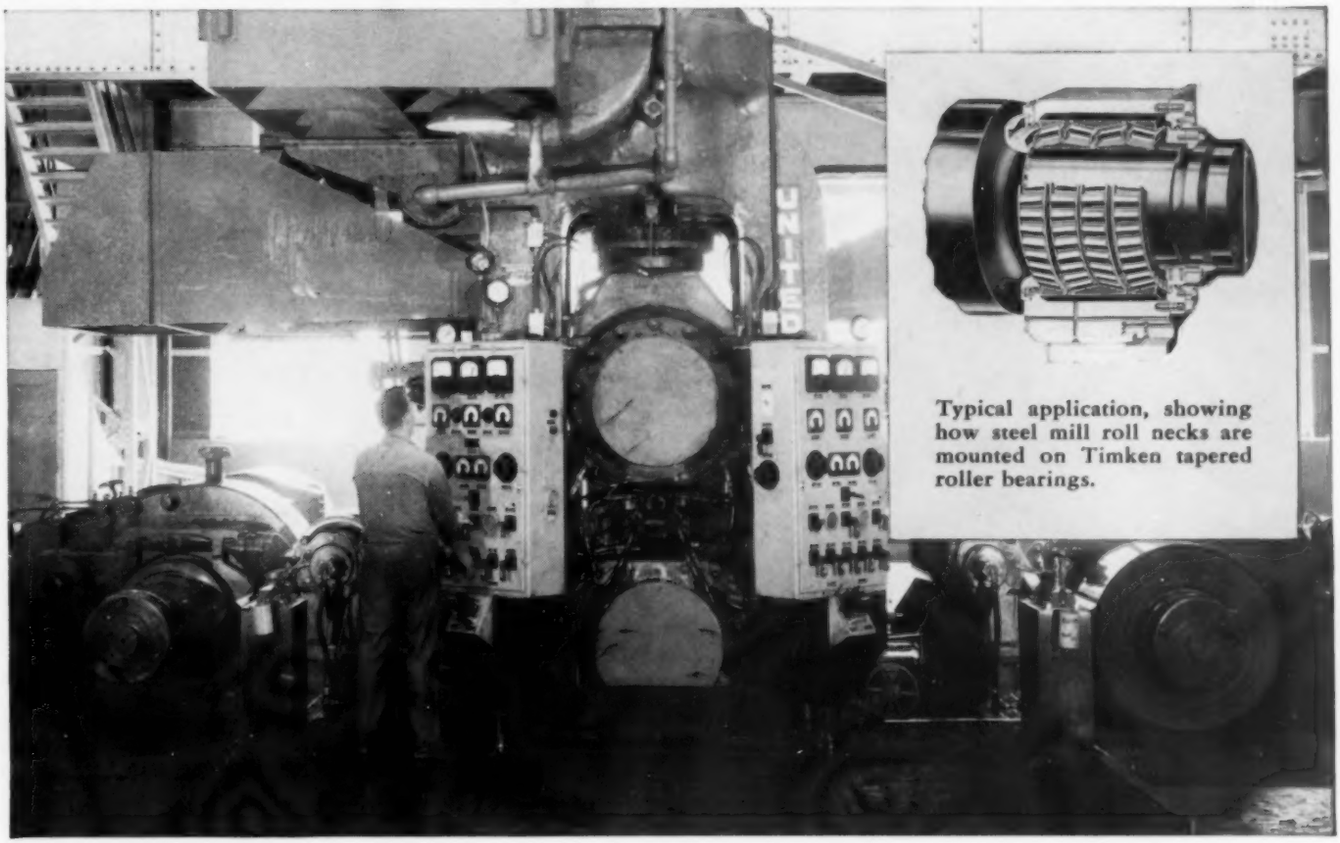
ELECTRONIC INSTRUMENTS BY BRISTOL

Free-Vane* Electronic Pyrometer Controller.

**BRISTOL** TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

# Scrap loss minimized with reversing cold mill back-up rolls on TIMKEN® bearings



Typical application, showing how steel mill roll necks are mounted on Timken tapered roller bearings.

THE back-up rolls on this United Engineering 6″ & 34″ x 30″ 4-high reversing cold mill at Allegheny Ludlum's Leechburg plant are mounted on Timken® tapered roller bearings. Timken bearings give low torsional resistance, regardless of operating speed or load. This eliminates the need for altering or relieving screw-down pressure — maintains gauge which minimizes scrap loss at each end of the coil. Less hydraulic accumulator pressure is needed with rolls driving easier on Timken bearings, which reduces bearing wear, cuts maintenance cost.

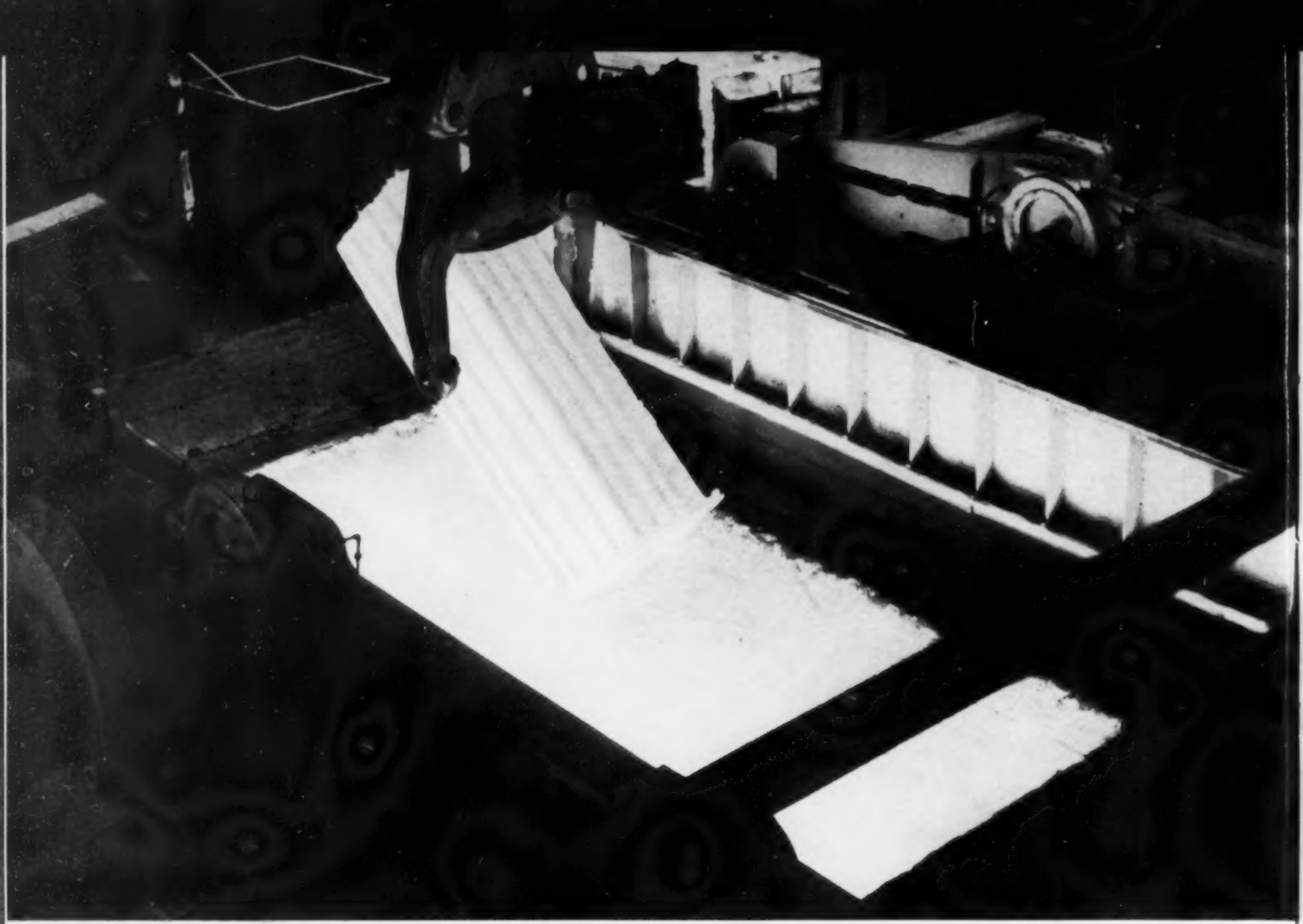
The balanced proportion design of Timken bearings provides maximum capacity in a given space. Timken tapered roller bearings give you greater mill rigidity, permit large diameter roll necks. They take both radial and thrust loads in any combination, require *no extra thrust devices*—which means more compact chuck mountings, simplified mill design. And by holding mill rolls rigid, Timken bearings help insure "on-gauge" operation, cutting scrap loss and reducing still further the cost per ton of steel rolled.

With Timken bearings, roll and chuck are held concentric, making closures more effective. There's less leakage of lubricant. And with economically grease-lubricated Timken bearings, lubrication requires no tubes, pipes or reservoirs. When you build or buy machinery, look for the trademark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

*This symbol on a product means its bearings are the best.*

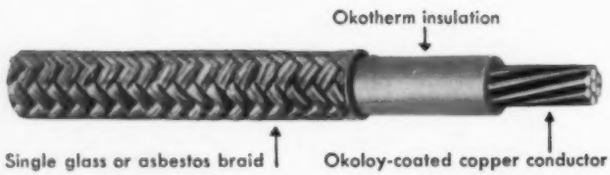
**TIMKEN** *TAPERED ROLLER BEARINGS ROLL THE LOAD*

TRADE-MARK REG. U. S. PAT. OFF.



The soaking pit—a typical power and control circuit application for Okotherm-insulated wires and cables.

# OKOTHERM . . . a service-proved electrical insulation for high ambient temperatures




Used on overhead cranes in open hearth rooms and around soaking pits, as power feeders, motor, control, and lighting circuits, wherever high temperatures are routine, Okotherm-insulated cables have set amazing records for service life.

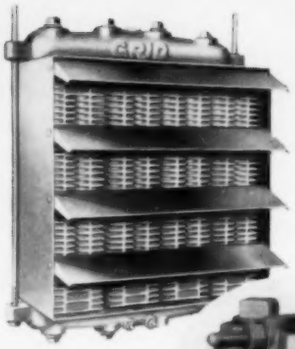
Why? They offer all the characteristics essential for dependable circuit operations in these high temperature locations. Extraordinary heat resistance . . . high temperature compressive strength . . . all-temperature flexibility . . . resistance to ozone . . . high dielectric strength—all these mean greater reliability, longer service in locations too hot for other cable constructions.

Okotherm is a thermosetting insulation compounded of silicone rubber. It is an almost entirely inorganic, Class H insulation that may be used for continuous operation at 150C (as high as 200C under certain conditions).

Okotherm-insulated wires and cables are available with a protective covering of glass, asbestos, orlon or nylon braid; and if required, a seamless aluminum sheath overall. For complete details contact your local Okonite Representative . . . or write for Bulletins IS-2117 and IS-1088. The Okonite Company, Passaic, New Jersey.

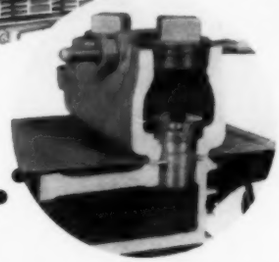
4902

*where there's electrical power . . . there's* **OKONITE CABLE**

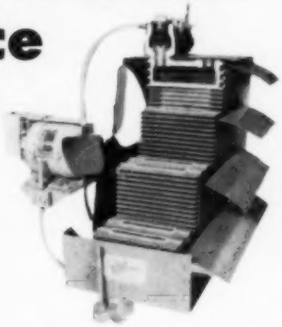


# GRID

* Cast Iron - Steam Heat Transfer Surface



## *ends Unit Heater Maintenance Problems!



Cut-away view of Model 2000 GRID Unit Heater. . . note double steam chambers in each fin section and wide fin spacing. . .fins are cast integral with steam chamber.

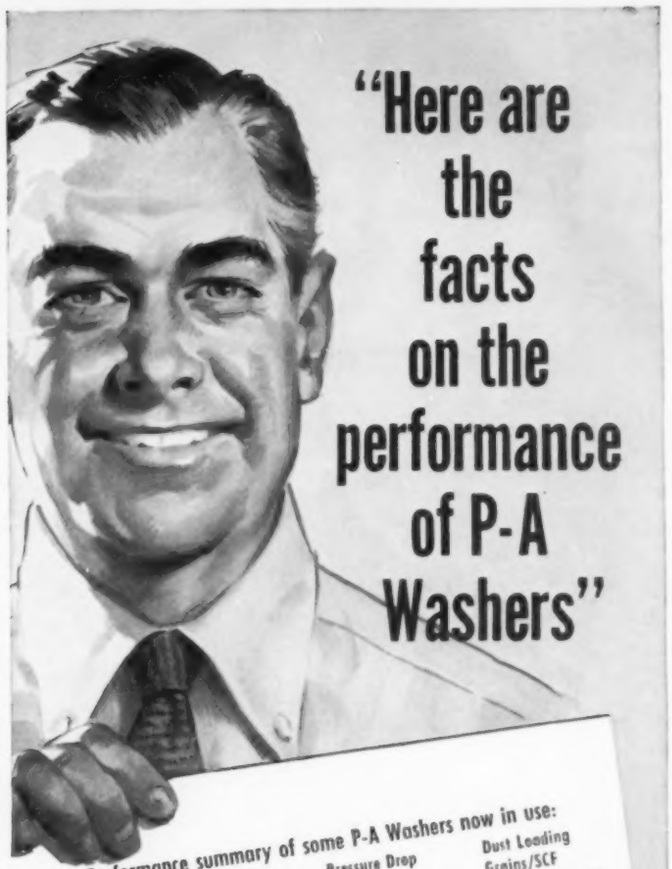
Your answer to unit heater problems the steel industry has discovered through common failures of copper, aluminum, and steel tube heat transfer surface. GRID condenser eliminates internal electrolytic corrosion—because all metals in contact with steam are similar. GRID also eliminates external corrosion—because the cast iron construction resists acid or other fumes in the air and eliminates the use of reducing valves where high steam pressure is used. GRID cast iron construction is tested to withstand steam pressures up to 250 P.S.I. . . . 450° temperature. GRID is built to last for years . . . uninterrupted service records of more than twenty years are common among GRID users in the steel industry.

Send for the complete story on GRID Unit Heaters, GRID Blast Heaters, and GRID Radiation for Steel plant use. . .it is contained in GRID Products Catalog No. 956. Write today for your copy.

**D. J. MURRAY MANUFACTURING CO.**

MANUFACTURERS SINCE 1883

WAUSAU, WISCONSIN




Performance summary of some P-A Washers now in use:

| Installation | Years Operated | Volume SCFM | Pressure Drop Inches Water | Dust Loading Grains/SCF Inlet | Outlet |
|---|---|---|---|---|---|
| | | | | 3-19.0 | .01-.04 |
| | 4 | 78,000 | 30 | 2-3 | .02-.08 |
| A | 3½ | 78,000 | 30 | 2-3 | .01-.03 |
| B | 3 | 85,000 | 30-40 | 2 | .02-.03 |
| C | 3 | 45,000 | 30 | — | .02 |
| D | ½ | 75,000 | 50 | 5 | .10 |
| E | ½ | 26,000 | 12 | 5 | .10 |
| F* | ½ | 26,000 | 12 | — | .04 |
| G* | ½ | 90,000 | 29 | | |
| H | | | | | |

*Two units in parallel on one furnace. Lower efficiency due to lower available top pressure

These actual performance figures reflect the highly efficient operation of the Pease-Anthony washer. This venturi scrubber puts your full top pressure to work cleaning the gas. No secondary cleaner required for most installations. Present users report no maintenance problems. If you have a blast furnace scheduled for construction or rebuilding, plan now for P-A Venturi installation. Capacities up to 150,000 SCFM. Write for bulletin M-103.

# CHEMICO

## P-A GAS SCRUBBERS

**CHEMICAL CONSTRUCTION CORPORATION**

*A Subsidiary of Electric Bond and Share Company*

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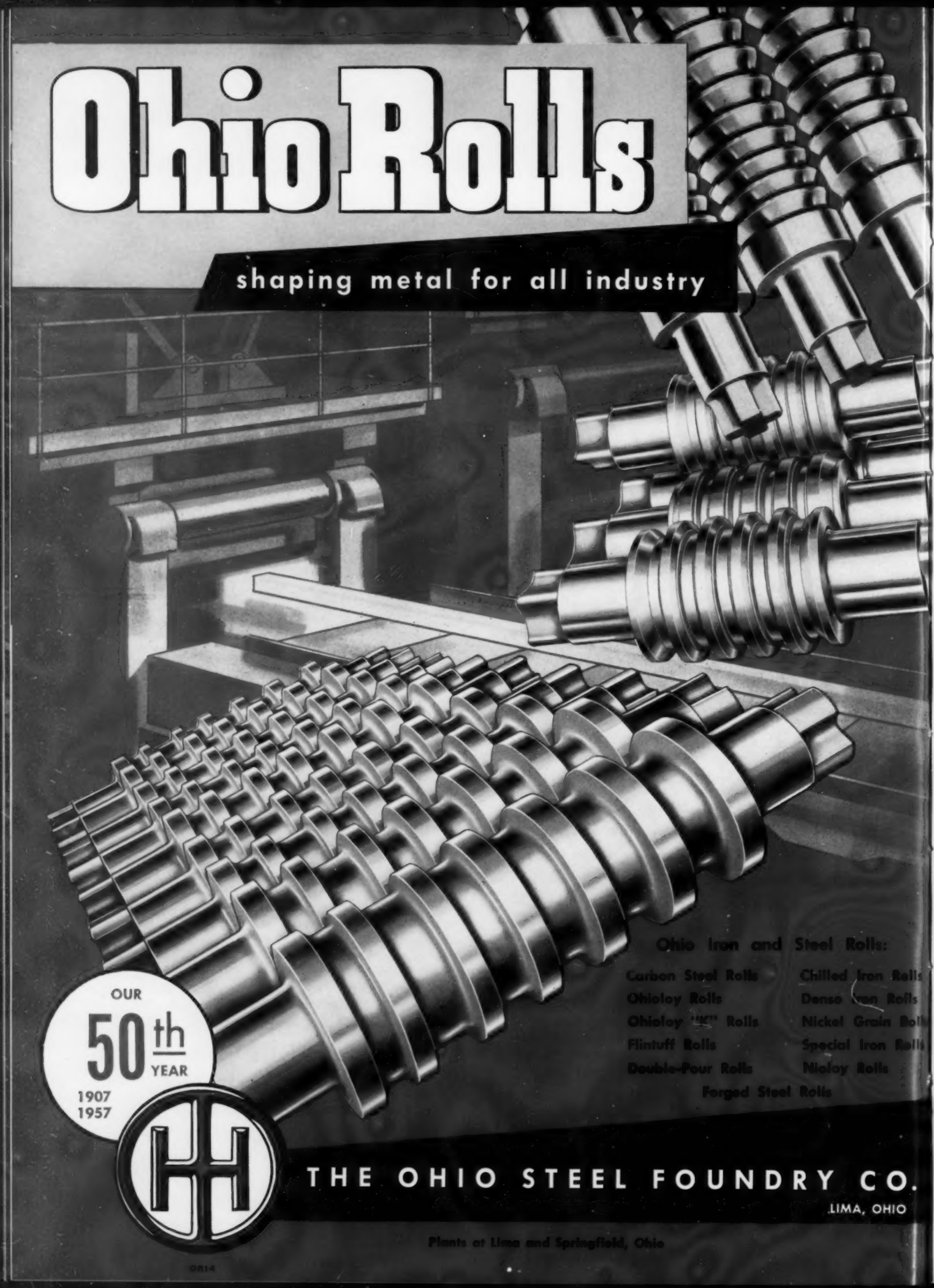
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Chilled Iron Rolls
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# Industry News...

## McLOUTH STEEL CORP. AWARDS CONTRACT FOR ADDITIONAL FACILITIES AT TRENTON WORKS

▲ A multi-million-dollar "package" contract to furnish and erect additional facilities at McLouth Steel Corp.'s Trenton, Mich., Works has been awarded to Dravo Corp. This is the second contract of its type awarded by McLouth to Dravo in the last four years. The contract includes a complete iron ore sintering plant, expansion of the present boiler plant and installation of a fourth boiler, additions to the pump house which will increase pumping capacity by more than 50 per cent, and extension of the river dock and ore storage yard.

With the exception of the sintering plant, all work involves facilities completed in 1955 under Dravo's original contract. These must be enlarged to meet the demands of McLouth's current expansion program, which includes erection of a second blast furnace and lengthening of the ore storage yard.

The Dravo-Lurgi sintering plant includes a 2000-ton per day sintering machine, straight line cooler, mixing and storage bins, Dravo-Schenck screens and other necessary equipment.

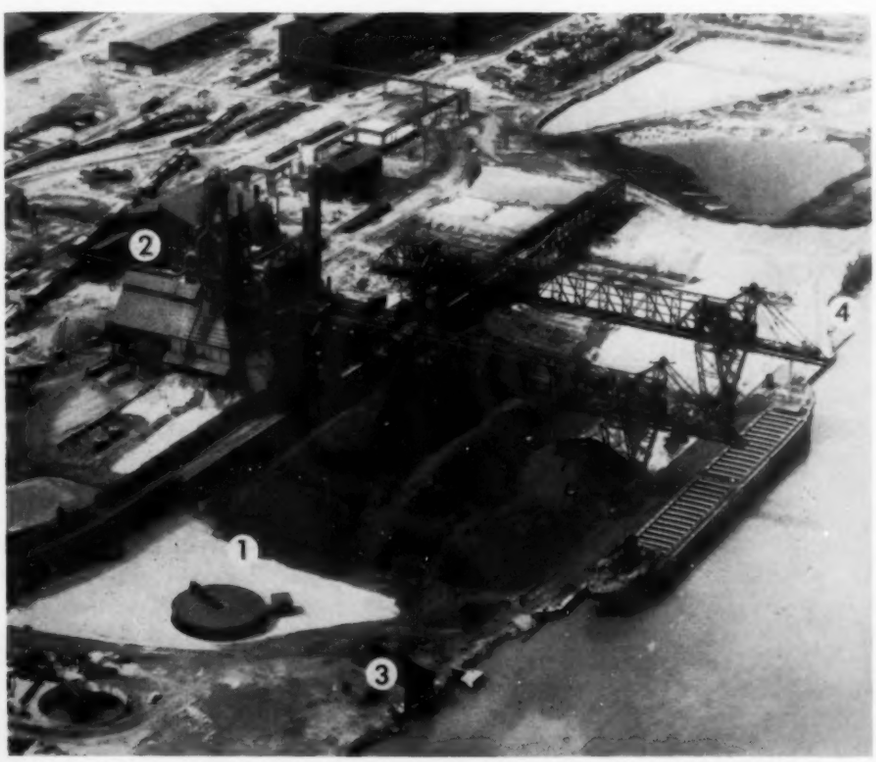
Expansion of the boiler plant includes the addition of four 19-ft-wide bays at the south end of the building and the installation of a 120,000-lb-per-hour, high pressure boiler, with a deaerating system and pump auxiliaries.

A 25,000-gallon-per-minute centrifugal pump will be installed in the completely automatic main pump house. Water requirements currently are filled by three 15,000-gallon-per-minute pumps. The new pump will deliver against a pressure of 75 psi and will be driven by a 1500-hp synchronous motor.

Dravo will add 423 ft to the 777-ft cellular sheet pile dock previously built adjacent to the ore yard. The new section will consist of 14 diaphragm type cells, faced with a continuous fender system of timbers.

Concrete walls carrying rails for the plant's two ore bridges will be extended for a similar distance. The larger of these walls, at the shear leg of the bridge, will be more than 20 ft high and almost 17 ft wide at the base, supported on steel pipe piles.

**New facilities at McLouth's Trenton Works will include (1) a sintering plant; (2) expanded boiler plant; (3) additions to the pump house; and (4) extension of the river dock and ore storage yard.**




## J & L TO PURCHASE PROPERTY IN OHIO

▲ Jones & Laughlin Steel Corp. announced that it has reached an agreement to purchase certain property of The Louis Berkman Co. at Louisville, Ohio.

The property, which consists of land and buildings, will be used by J&L for installation of flat rolling equipment for its Stainless Steel Division, according to Avery C. Adams, J&L President.

"Purchase of this property will allow us to begin production of stainless steel sheets without the delay we would have had in acquiring a site and constructing buildings," said Mr. Adams.

Mr. Adams added that he expects actual operations to begin in the third quarter of 1958.

In the transaction, J&L will acquire buildings with a total area of about 260,000 sq ft, and 140 acres of real estate.

## WILL IMPROVE PIPING OPERATIONS AT BENWOOD

▲ Details of the $4,500,000 improvement program at Wheeling Steel Corp.'s Benwood Works were announced by P. W. Koenemund, vice president in charge of operations and engineering.

He explained that major pipe finishing operations at Benwood are presently located in three separated areas. Pipe warehousing and shipping operations are similarly scattered. Plans are to consolidate the various related operations.

The present pipe warehouse building will be enlarged and converted to a combined finishing department. A new modern pipe warehouse building is to be constructed.

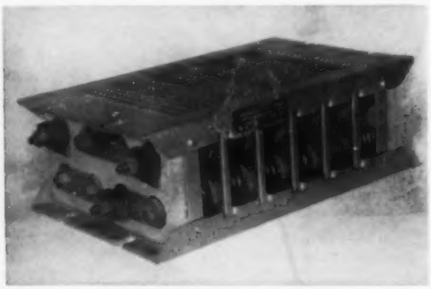
# GUYAN
## RESISTORS

**Engineered and designed to eliminate resistor maintenance on troublesome mill applications.**

**Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.**

**Sturdy, rugged steel construction eliminates shock and vibration troubles.**

**Custom designed for your conditions including excessive graphite accumulations.**



**With a quarter century of resistor engineering, we invite you to take advantage of our experience.**

**For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.**

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Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—Mechanical Equipment Co., 3100 Prospect Ave.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

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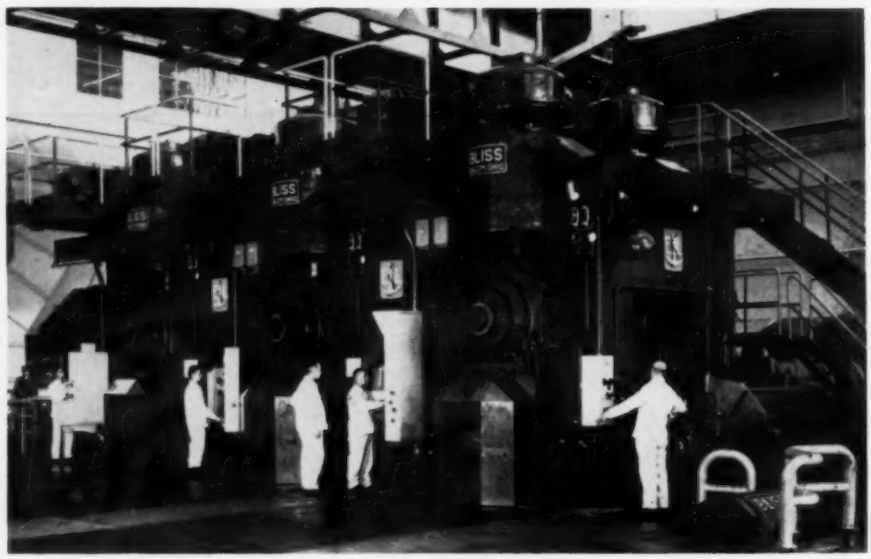
Pittsburgh 27, Pa.—P. R. Holden, 4860 Elmwood Dr.

●

**GUYAN MACHINERY COMPANY**

**LOGAN, W. VA.**


## THREE-STAND ROLLING MILL OPERATING IN BELGIUM



**The first multiple-stand rolling mill of large size to be erected in any of the Benelux countries is now in operation at the plant of Society Anonyme Metallurgique d'Esperance Longdoz in Liege, Belgium. Designed and built by E. W. Bliss Co., the three-stand four-high mill will produce upwards of 400,000 tons per year of high quality cold rolled steel. Provision has been made for the addition of a fourth stand at a later date. The mill rolls 52-in. steel strip down to 0.024-in. thickness at a delivery speed of 900 ft, and is designed so that it can be conveniently speeded up at a later date. Air operated sticker type entry guides are installed on each of the three mill stands, so that manual operations have been almost completely eliminated in feeding strip into and through the mill. All three mill stands are similar, with alloy forged steel work rolls 21 in. in diameter and 58 in. wide. Backing rolls of alloy cast steel have a diameter of 53 in. and are 56 in. wide. Backing rolls on all three stands are serviced by a central lubricating system, which has been made large enough to handle the contemplated fourth stand.**

The yard tower crane and runway south of the present warehouse will be replaced by an open crane runway equipped with two electric overhead traveling cranes.

Major railroad track changes will be made to service the new warehouse and finishing areas and to permit greater utilization of the plant area in the event of further expansion.

## TO REBUILD FURNACE AT PITTSBURGH WORKS

▲ No. 2 Blast Furnace at the Pittsburgh Works of Jones & Laughlin Steel Corp. has been "blown out" for a complete rebuilding job.

The furnace, originally constructed in 1898, will be rebuilt from the ground up, according to Walter H. Lewis, Works Manager, J&L's Pittsburgh Works Division. Its hearth will be enlarged from the present size of 21 ft, six in. to 26 ft, six in., and it will become the largest furnace at the Pittsburgh Works with a working volume of 41,236 cu ft No. 2 furnace was last relined in 1952.

The daily capacity of the furnace will be enlarged from about 800 net tons of pig iron to about 1300 net tons. Its yearly capacity will be increased to more than 400,000 net tons.

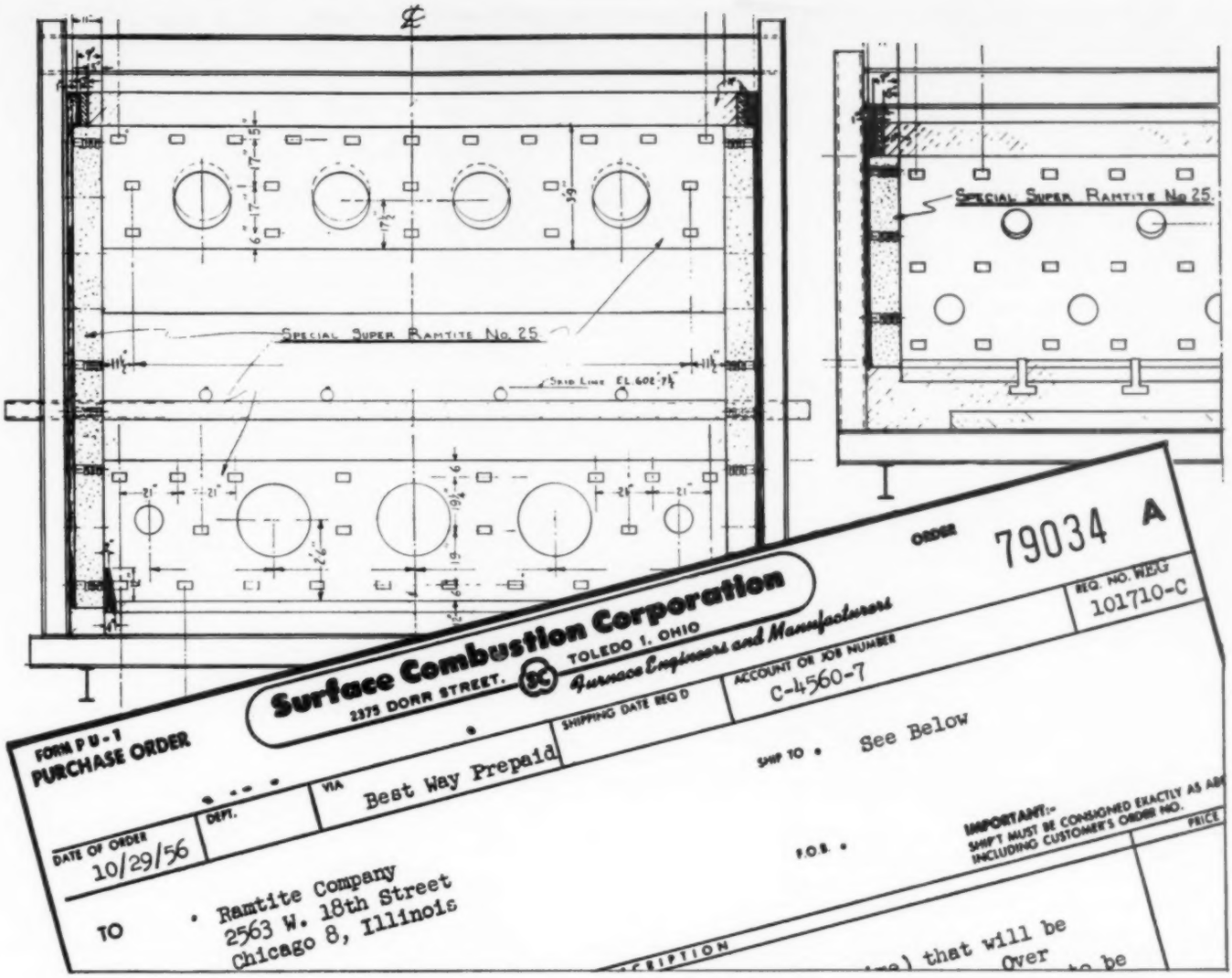
J&L operates five other blast furnaces in the Eliza group at the Pittsburgh Works.

The entire project is expected to be completed within six months, Mr. Lewis said.

## WILL DISCONTINUE ZINC SMELTING AT DONORA

▲ The smelting of zinc at U. S. Steel Corp.'s American Steel and Wire Plant, Donora, Pa., will be discontinued around November 1. Operation of the Donora Steel and Wire Works will not be affected by this action.

Built over forty years ago in 1915 to insure a steady supply of zinc to




# Four more NEW Surface® slab heating furnaces with RAMTITE® side and burner walls

In slab heating furnaces as in other steel mill applications, it's performance that counts. We feel that is the reason for the ever increasing use of Ramtite by steel mills and furnace designers throughout the nation—and for the above purchase order for Ramtite to line the side and burner walls in these new 135 ton triple fired furnaces.

Ramtite performance in similar furnaces has resulted in:

1. *Increased furnace capacity*—high thermal efficiency permits a 25% to 30% reduction in thickness over standard wall construction.

2. *Fuel savings*—monolithic construction eliminates joints, reduces air and gas leakage as never before.

3. *Low maintenance*—inherent spall resistance assures longer refractory life.

The Ramtite Co. offers you a complete sales engineering service—experienced men who are always available to study your refractory problems and consult with your engineering, mason and ceramic departments about your specific needs.

For further information, contact your local Ramtite representative.

***Ramtite is our business . . . not a sideline.***

**The Ramtite Co.**
DIV. OF THE S. OBERMAYER CO.

**1813 South Rockwell Street** **Chicago 8, Illinois**

© 1957 This is another in a series of advertisements depicting ways Ramtite Refractories serve the steel industry.

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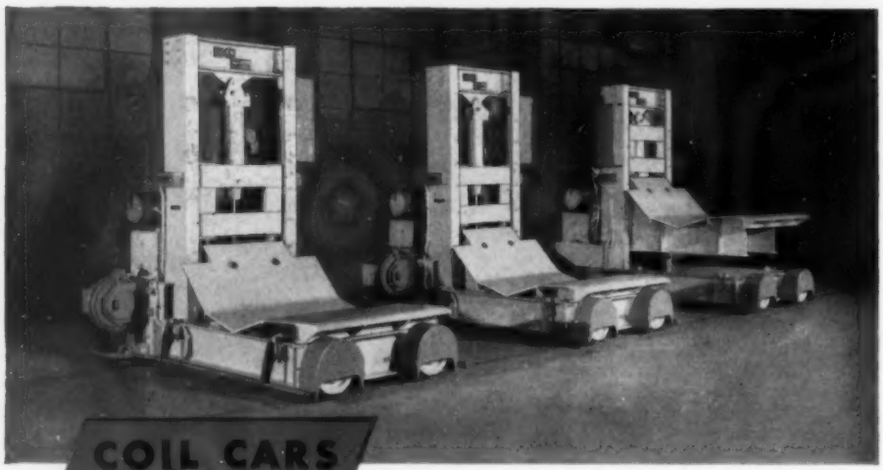
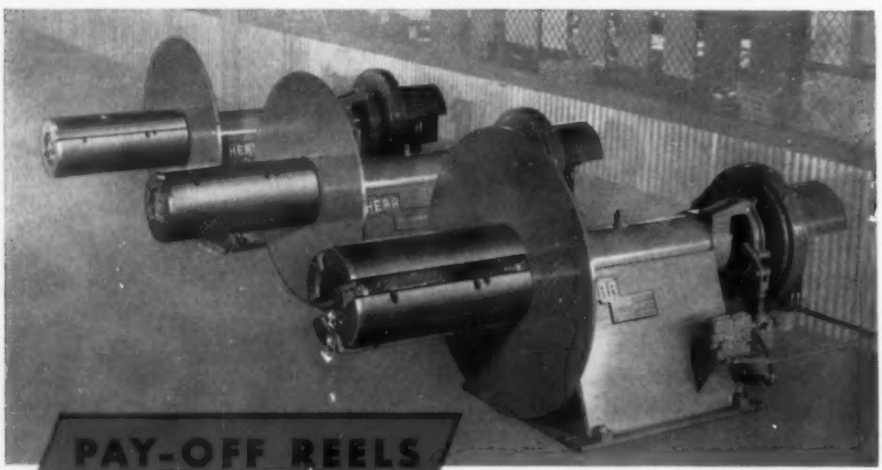
"Complete Processing and Handling Equipment . . . for any Ferrous or Non-Ferrous Material . . . That Starts — or Ends — as a Coil"



COIL CARS

For fast, efficient loading of pay-off reels and unloading of coiling reels. Sizes to handle coils of any diameter, width or weight. Hydraulic lift, electric traverse. No pits. Can be fitted with coil ejector, up-ender and other accessories if desired. Furnished complete ready for use.



PAY-OFF REELS

Types and sizes for coils weighing from 5,000 to 50,000 lbs. and up to 84" wide. Fixed, adjustable or automatically aligning bases. Timken bearings. Can be equipped with threading drive, also automatic speed compensating drive for feeding presses.

Write for fully descriptive Bulletin No. 561 today!

THE HERR EQUIPMENT CORPORATION

1270 VINE STREET • WARREN, OHIO

CLEVELAND, INDIANAPOLIS AND BERKELEY, CALIFORNIA

U. S. Steel manufacturing units, the zinc smelting operations are no longer economical, and plentiful supplies of zinc are available at prices lower than the cost of manufacture at the Zinc Works.

The sulphuric acid plant at the works will continue operation.

At the present time plans call for dismantling of certain structures shortly after termination of zinc production at the plant. Some of the buildings are expected to be used to supplement other operations in Donora. The property on which the zinc plant is located will be retained by American Steel and Wire to provide for possible future expansion.

Originally constructed primarily for the production of zinc and sulphuric acid, the plant ultimately was expanded to include other auxiliary facilities to bring annual capacity up to 70,000 net tons of slab zinc and 160,000 net tons of sulphuric acid, in addition to smaller amounts of cadmium, germanium and other by-products.

## ILLINOIS GEAR EXPANDS AT ITS SOUTH WORKS

▲ The Illinois Gear & Machine Co. has announced a $2,000,000 expansion program for its South Works in Chicago, Ill. Building construction will double the size of its heavy manufacturing division. More than half of the expenditure is represented by heavy machine tools.

The expansion will also make available at the main plant considerable manufacturing space in which it is planned to install a considerable quantity of smaller production machine tools.

## PURCHASES SINTERING UNIT FROM GOVERNMENT

▲ Purchase of a sintering unit at its Hamilton, Ohio, plant which it had been leasing from the Federal government since 1943 was announced by Armco Steel Corp.

The announcement was made by R. S. Gruver, Armco administrative vice president, who said that Armco and the General Services Administration had agreed on a purchase price of $580,000.

The installation was built by the Reconstruction Finance Corp. in the early stages of World War II. Designed to recover flue dust and

iron ore "fines" and thus conserve raw materials and increase blast furnace pig iron production, the sintering unit went into operation in April, 1943. It has been operated continuously by Armco since that time.

D. S. Holstein, manager of the company's Middletown Works, said that no changes are planned in the operation of the sintering unit. It now serves three blast furnaces—two at Hamilton and one at Armco's Middletown plant.

## SKF, INC. ACQUIRES TYSON BEARING CORP.

▲ Acquisition of the Tyson Bearing Corp., Massillon, Ohio, was announced by Edwin R. Broden, president of SKF Industries, Inc.

SKF acquired a controlling interest in Tyson more than two years ago, and recently increased stock ownership to almost 100 per cent.

Mr. Broden said that the experience with Tyson as a subsidiary has indicated the desirability of making the change in the corporate structure, and that, with this change, the new division would be known as the Tyson Bearing Co., division of SKF Industries, Inc.

Business will be conducted at the general offices in Massillon, Ohio, as it has in the past. A. Stewart Murray, formerly assistant to the president at SKF, has been president of the Tyson Bearing Corp. since December, 1955, and will continue as president of the new division.

## TO REBUILD BATTERIES AT CLEVELAND WORKS

▲ A contract to rebuild two coke oven batteries and furnish certain chemical recovery and coke handling equipment at Republic Steel Corp.'s Cleveland, Ohio, works, has been awarded to Koppers Co., Inc.

The new 51-oven batteries will replace batteries built in 1918. When completed, each battery will have a capacity of carbonizing 1000 net tons of coal per day to produce 700 net tons of furnace coke per day. Auxiliary equipment will include a new coke screening system and surplus gas boosters. At the present time Koppers is rebuilding another 51-oven battery at Republic's Cleveland works which will be placed in operation within the next few months.

Preliminary work has already begun on the new batteries with work in the field to begin sometime this summer. Rebuilding the batteries and the installation of new auxiliary equipment is expected to be finished in the summer of 1958.

## AWARDS CONTRACTS TO SALEM-BROSIUS

▲ Contracts to design and build nine soaking pits, a charging machine and a number of materials handling trailers have been awarded to Salem-Brosius, Inc., by Lukens Steel Co.

The contracts were awarded through United Engineers and Constructors, Inc., the firm in charge of the Lukens construction program.

The soaking pit installation is made up of three batteries of three pits each. The pits are 26½ x 11½ ft and about 19 ft deep. Each pit is fired by two burners mounted in one end wall, and products of combustion are flued out of the furnace near

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A-B-K bearings won't peen, score or heat check your heavy roll and spindle parts, sharply reduce downtime and maintenance costs per ton rolled. Made of laminated phenolic fabric, they have the ability to absorb and cushion heavier impacts—and often outwear metal bearings many times. When replacements *are* necessary, downtime is reduced because A-B-K bearings have fewer parts, are lighter in weight, easier to handle. Ask our engineers for specific recommendations.

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- Won't score
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- Cut lubricant costs
- Save power

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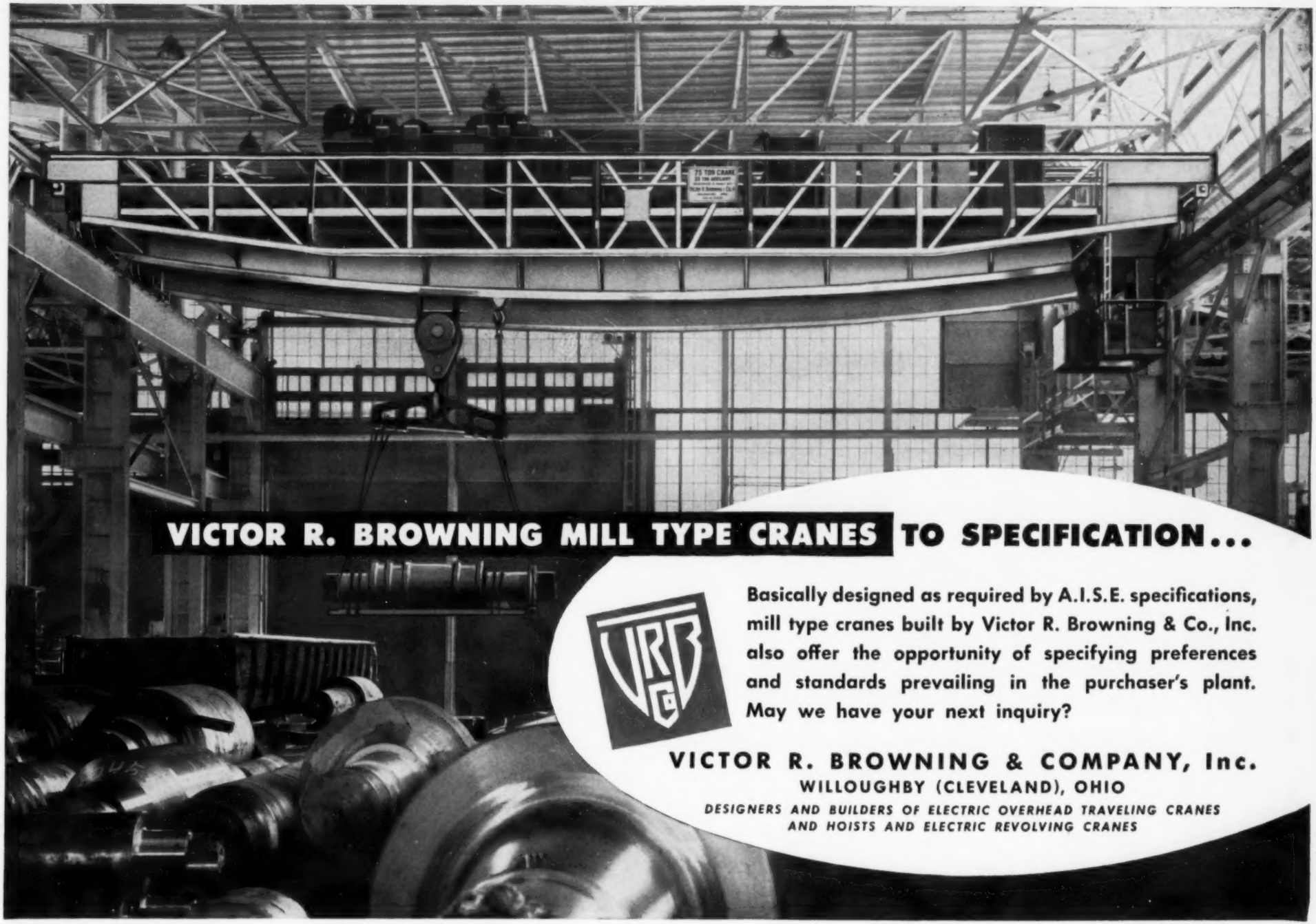

# VICTOR R. BROWNING MILL TYPE CRANES TO SPECIFICATION...

Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

**VICTOR R. BROWNING & COMPANY, Inc.**

WILLOUGHBY (CLEVELAND), OHIO

*DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES*

the bottom of the pits in the burner wall.

The pits will be equipped with needle-type metallic recuperators, the recuperator installation consisting of two double-pass units for each battery of three pits. Thermal Transfer Co. will supply the recuperators.

The pits will be equipped to burn either natural gas or bunker "C" oil, with a designed fuel input per pit of 30,000,000 BTU per hour, based on heating charges weighing about 200 tons.

The charging machine is a 12,000-lb capacity unit, driven by a diesel engine, and will charge boxes of alloy, scrap and lime additions to the melting furnace.

## DUQUESNE WORKS WILL ADD NEW ROLLING MILLS

▲ Construction of modern, high speed rolling mills replacing the present facilities for the production of billets, blooms and slabs will soon get under way at Duquesne Works, United States Steel Corp.

Work will begin immediately on engineering details for the three new mills, and actual construction will commence in about three months. The mills will be located in a new plant building between the Monongahela River and the present bar mills at Duquesne.

The new facilities will consist of three rolling units, a 46-in. high lift slabbing - blooming mill, 36-in. blooming mill and a four-stand continuous 21-in. billet mill consisting of two vertical and two horizontal stands. Each of the rolling mills will be fully automatic, having their own shears and mill outlets including facilities to handle the finished product.

The program also provides for the installation of seven banks of soaking pits; a new stripper building; and a new shipping building.

## *Meetings*

▲ An International Symposium on the Annealing of Low Carbon Steel will be held in Cleveland, Ohio, on the campus at Case Institute of Technology, October 29 and 30.

The symposium will be jointly sponsored by the Lee Wilson Engineering Co., Inc., of Cleveland and Case Institute of Technology.


ANNOUNCING...

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DIAMOND "UtiliVue" MODEL 500 CAMERA SYSTEM

This new industrial television camera and control unit provide a sharper picture with finer detail. The 500 has automatic compensation for wide variations in light on the scene viewed . . . assuring a good picture with any reasonable illumination. Picture quality is maintained automatically under wide fluctuations in line voltage.

The miniaturized camera is exceptionally compact and easy to use. The controls are simple and can be remotely located from the camera. As many as five cameras can be used with one control unit by means of a Diamond camera switcher.

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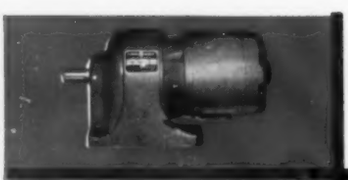
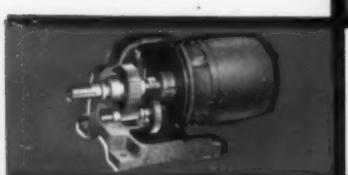


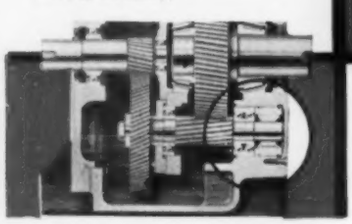
**UTMOST COMPACTNESS** is provided by flanged connection of motor to gear drive.

**STANDARDIZED FLANGE** (one size per motor) permits use of more universally applicable motor.



**BUILT-IN ALIGNMENT** is provided through use of the rabbet-fit NEMA motor.

**EFFECTIVE SEALS** at all shaft openings keep oil in and prevent dirt from entering housing.



**INTEGRAL BACKSTOP** to prevent reverse rotation. Can be installed at any time without additional parts or modifications.

## LINK-BELT GEARMOTORS maintain positive alignment with flange-mounted NEMA motors

Here's space-saving speed reduction that's made-to-order for tight drive locations. First, because the speed reducer itself is extremely compact, thanks to Link-Belt's advanced gearing methods. Second, the motor is flange-mounted, with no need for coupling devices.

In response to the tremendous demand for these new Gearmotors, Link-Belt can now offer delivery from stock for sizes up to 30 hp, speeds from 280 down to 6 rpm. For details, contact your Link-Belt office or authorized stock-carrying distributor.

Ask for new 28-page Book 2447—offering details of design highlights plus complete engineering data.

**LINK-BELT**

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**LINK-BELT COMPANY:** Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.317

# NOTHING WEARS OUT
# in the BAILEY AREA METER
## for flow measurement

Simple design and sturdy construction in the Bailey Area Meter mean virtually no maintenance. Grit and dirt in liquid fuels do not harm this meter. Thus, long, trouble-free service under demanding steel mill conditions is assured.

**Stainless steel** is used for all vital operating parts, so meters can handle corrosive fluids and withstand corrosive atmospheres associated with steel making. Whether you are metering oil, pitch, or tar for open hearth fuel, water for a pickling process or any of a number of other fluids, you can install a Bailey Area Meter in the line and forget it.

**The principle of operation** is simplicity itself. The metering plug moves directly proportional to rate of flow.

**Pneumatic Area Meter Transmitters** indicate flow and provide a signal of 3-15 psig or 3-27 psig for indicating, recording, and controlling. Electric Area Meter Transmitters are also available. Both types are useful for fuel totalizing and/or control.

**In a typical steel mill** application, a Bailey Area Meter is used to measure the flow of Bunker C Oil and pitch to an open hearth furnace. A control system operated by the Area Meter maintains constant flow rates as determined by the operator based on temperature of the molten metal and the roof temperature. After each use of pitch, the meter is steamed out, thus making it available for fuel oil. The thermal and mechanical shock of steaming has no effect on the $\pm 1\frac{1}{2}\%$ accuracy.

**The Bailey Area Meter** measures flow over a 50 to 1 range. Range spans are 0-550 lb/hr to 0-108,000 lb/hr. The Bailey Recorder used in conjunction with the transmitter may be calibrated in terms of gallons, pounds, or cubic feet per minute. It receives and continuously records one to four pneumatic or electric signals in any combination.

A Bailey Engineer will be glad to call at your plant and explain how you may use this meter. Or, you may wish to write our Iron & Steel Division for Product Specifications P22-4 and E22-4. S-7-1

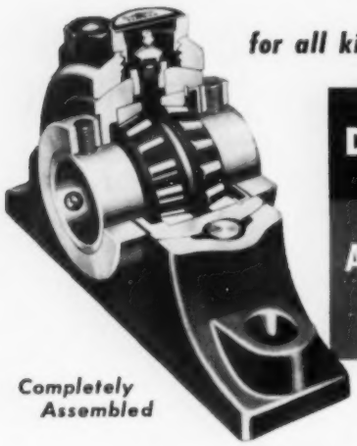
***Instruments and controls for power and process***

# BAILEY METER COMPANY

***IRON AND STEEL DIVISION, 1047 IVANHOE ROAD, CLEVELAND 10, OHIO***

**In Canada—Bailey Meter Company Limited, Montreal**

BAILEY METERS



*for all kinds of service*

**DODGE-TIMKEN**

**America's Quality Pillow Block**

*Completely Assembled*

*Pre-Lubricated*

*Factory Adjusted*

Where service conditions are toughest Dodge-Timken Bearings prove their quality by superior performance, dependability and long life. Protected both on and off the shaft; delivered ready to mount. Available in five types—the Type E . . . Double Interlock (illustrated) . . . Type C . . . Special Duty . . . and All-Steel. Shaft sizes from 1-3/16" to 10". Write for Bulletin A638 giving load ratings, dimensions and other data.

**Dodge Manufacturing Corporation, 5900 Union St., Mishawaka, Ind.**

**DODGE**

*of Mishawaka, Ind.*

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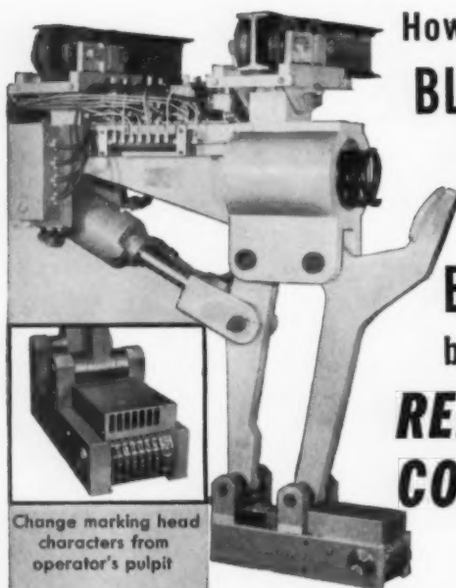


**How to mark BLOOMS, SLABS and BILLETS by *REMOTE CONTROL***



Change marking head characters from operator's pulpit

**Mecco SAFETY BILLET MARKER**

New marking head allows cut letters and ingot numbers to be changed instantly from the operator's pulpit. Wide versatility for stamping ends of blooms, slabs, and billets. *Write for Bulletin 613-D on new Billet Marker.*

A product of the Marking Device Industry

**M. E. CUNNINGHAM CO.**

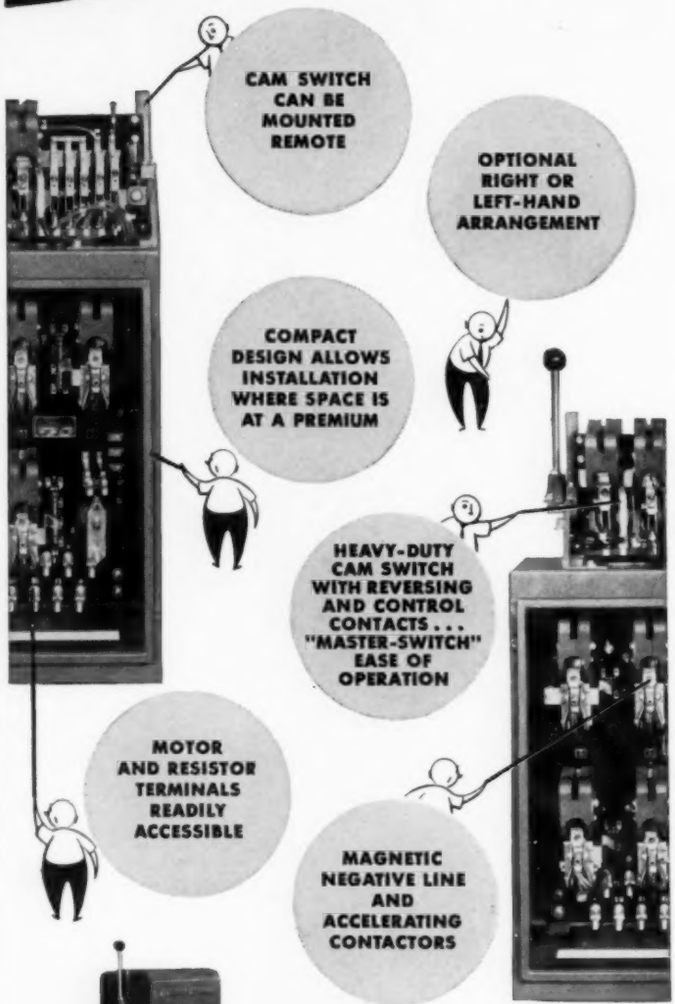
**1041 CHATEAU STREET, PITTSBURGH 33, PA.**

---

**NEW**

**HEAVY-DUTY D-C MAN-NETIC CONTROLLERS***

**COMBINATION MANUAL and MAGNETIC CONTROLLER FOR CRANES—CHARGING MACHINES—D-C CONTROL JOBS**


CAM SWITCH CAN BE MOUNTED REMOTE
OPTIONAL RIGHT OR LEFT-HAND ARRANGEMENT
COMPACT DESIGN ALLOWS INSTALLATION WHERE SPACE IS AT A PREMIUM
HEAVY-DUTY CAM SWITCH WITH REVERSING AND CONTROL CONTACTS . . . "MASTER-SWITCH" EASE OF OPERATION
MOTOR AND RESISTOR TERMINALS READILY ACCESSIBLE
MAGNETIC NEGATIVE LINE AND ACCELERATING CONTACTORS
TOE SPACE FOR OPERATOR'S COMFORT

**2 TYPES AVAILABLE: REVERSE-PLUGGING OR DYNAMIC - LOWERING**

Provide four speed points, reversing, with all advantages of full-magnetic control. Manually-operated cam contacts are free of destructive arcing . . . extremely fast magnetic contactor action interrupts power circuit before cam-operated contacts are opened. EUCLID'S EXCLUSIVE "TIMELOK" feature offers maximum dependable acceleration timing without extra relays . . . permits unusually compact arrangement of the magnetic panel.

**For more information, contact our representative in your area, or write or call THE EUCLID ELECTRIC & MFG. CO., MADISON, OHIO.**

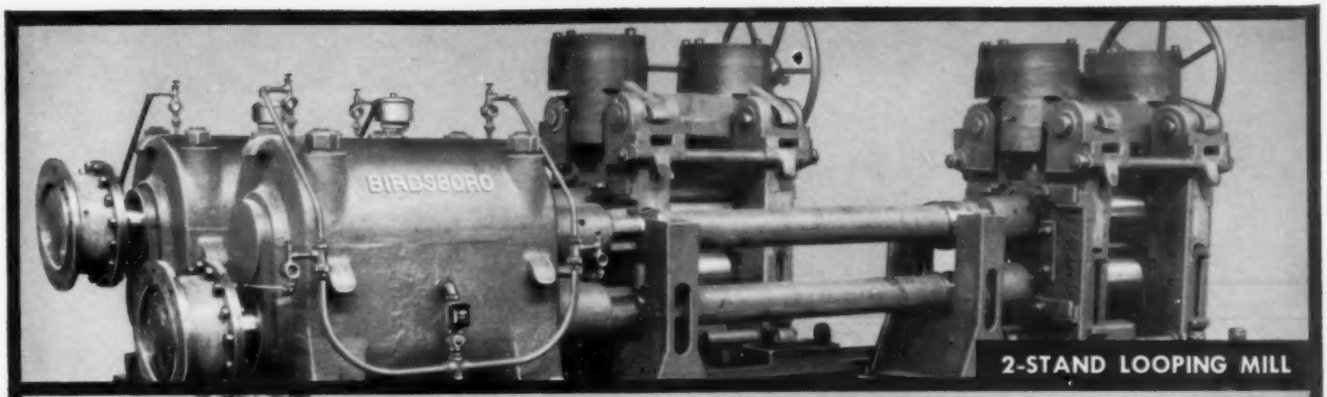
***Ask for Bulletin 4400-4401.***

***PATENT APPLIED FOR.**

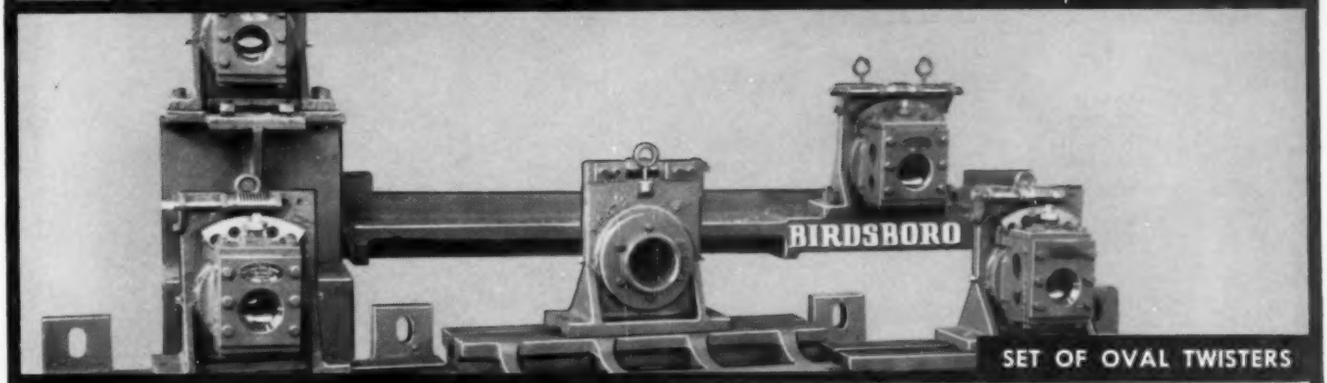
**THE EUCLID ELECTRIC & MFG. CO.**

**MADISON, OHIO**

THE EUCLID ELECTRIC **EUCLID** AND MFG. CO., MADISON, OHIO

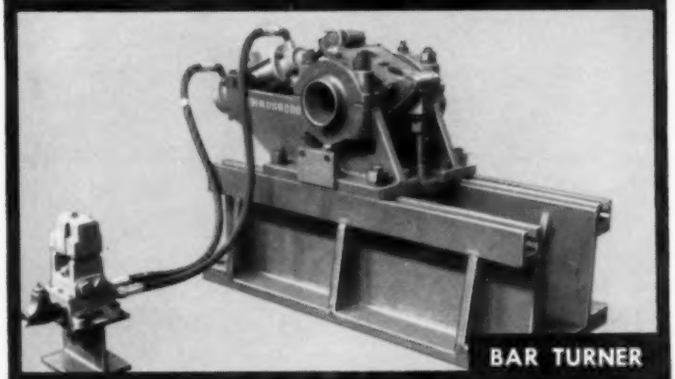



2-STAND LOOPING MILL

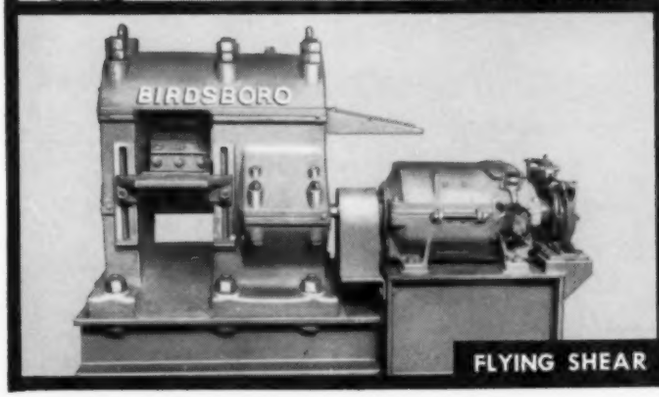



SET OF OVAL TWISTERS

REDUCTION GEAR DRIVE



BAR TURNER




FLYING SHEAR

## BIRDSBORO face-lifts rod mill with new additions to increase production quotas

This equipment was supplied by Birdsboro to revamp and modernize a specialty rod mill. By custom-designing special equipment, Birdsboro was able to help the client make important advances in productivity. There is almost no limit to the design versatility of the Birdsboro staff, even for the intricate requirements of a re-building program. From a single time and labor-saving unit to an entire mill, Birdsboro has more to offer your operation . . . call in a Birdsboro representative and find out why. Main office and plant: Birdsboro, Pa.

District Office: Pittsburgh, Pa., Subsidiary: Engineering Supervision Co., 120 W. 42nd St., New York 36, N. Y.

MM59-57

**BIRDSBORO**
STEEL FOUNDRY AND MACHINE CO.

STEEL MILL MACHINERY • HYDRAULIC PRESSES (Metalworking and Extrusion) • CRUSHING MACHINERY • SPECIAL MACHINERY • STEEL CASTINGS • Weldments "CAST-WELD" Design • ROLLS: Steel, Alloy Iron, Alloy Steel

# NATIONAL TRADE-MARK BRUSHES HELP SOLVE AUTOMATION'S BIGGEST PROBLEM:

## "adjustable speeds"

Economical M-G sets and D-C motors – using "National" brushes – supply the highly controllable power vital to self-correcting automated equipment.

Compact motor-generator unit combines A-C savings with D-C pin-point control

## Why these NATIONAL TRADE-MARK brush grades are best for automation:

**SA-45 SA-35 N-4**

- Superior commutating ability over a wide speed range
- Brush uniformity assures consistent machine performance
- Superior brush operation reduces expensive down-time and equipment maintenance

See your "National" Brush Man when you're selecting carbon brushes. He has a brush for every need, plus the experience and backing to help you assure continuous good performance.

UNION CARBIDE

*The terms "National", "Union Carbide" and the Silver Colored Cable Strand are registered trade-marks of Union Carbide Corporation*

NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • *30 East 42nd Street, New York 17, N. Y.*

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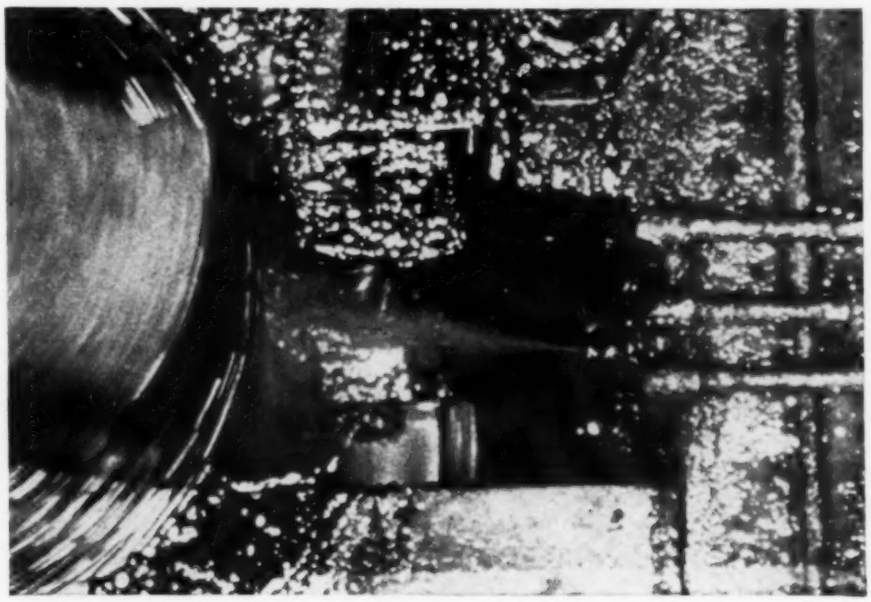
THE BROOKS OIL CO.

# Lub Engineering News

A REPORT ON THE DIFFICULT LUBRICATING PROBLEMS OF INDUSTRY



## SPRAY LUBRICATION OF ROLL NECK BEARINGS CUTS COSTS FIVE WAYS, STEEL MILL REPORTS

Lubrication of roll necks and bearings by means of a spray system employing a fluid lubricant, as shown in the unretouched photograph above, has proved far superior to the traditional system of forcing grease along grooves machined in the bearing surfaces, according to reports of an extended study recently completed by a major steel company.

Five major savings resulted from the use of the spray system:

1. The initial cost of preparing the bearings for service was reduced because it was not necessary to cut grease grooves. Also, the safe overall bearing area is substantially increased.
2. Lubricant consumption dropped from an average of 20 drums per week to approximately 3 drums.
3. Bearing life was substantially increased. With the old system of lubrication, bearings wore out in about 3 weeks. Bearings lubricated by the spray system showed no appreciable wear after 18 weeks of service.
4. Longer bearing and roll neck life also meant less time and cost for remachining and dressing.
5. Mill downtime was greatly reduced. With ordinary lubrication, 5 intervals of downtime would have been expected during the four months of the study period—with spray lubrication there was *no* downtime—saving thousands of dollars.

First adapted in 1949 and now being used by major steel companies for this important and severe application—the lubricant was Brook's Klingfast, a lead base fluid lubricant which retains its film strength (4 gram Timken test, 30 min. minimum—43 lbs. L.A.L.).

For complete data, write for Bulletin K-26.

## NEW COLOR FILM GIVES ANSWERS TO TOUGH LUBRICATION JOBS

Want to see how good lubricants get that way—lubricants for severe industrial applications, that is?

This new 30 minute 16 mm motion picture, in full color, with sound, shows a number of tough lubrication jobs. It pictures and describes the research, manufacturing and quality control methods that enable Brooks lubricants to "stand up" under severest service.

It's available to any supervisory or engineering group interested in lubrication problems. No charge, of course—we're glad to have you see it. Just call or write any of our offices and tell them you want to borrow "The Brooks Oil Story."

## HAVE YOU TRIED *Klingfast*® FOR OPEN GEARS?

Lubrication of open gears is one of industry's toughest jobs because of severe operating conditions in speed, vibration, shock, reversal, intermittent action, exposure to high temperature, contamination, and the added problems of inaccurate alignment, excessive clearance in bearings and incorrect contact of teeth surfaces. If you've been having open gear lubricating problems, write us about Klingfast. This lubricant has been the answer in many case studies.

## BROOKS LABORATORIES ARE AT YOUR SERVICE

Extensive research is constant with Brooks. Our laboratories are available at all times, with experienced and qualified personnel to serve your lubrication research and development needs.

THE BROOKS OIL CO. 81st YEAR 1876 1957

**THE BROOKS OIL COMPANY**

EXECUTIVE OFFICES AND PLANT—CLEVELAND, OHIO
EXECUTIVE SALES OFFICES—928 RIDGE AVENUE, PITTSBURGH 12, PA.
OFFICES AND WAREHOUSES IN PRINCIPAL CITIES

U. S. A.
CANADA
CUBA—S. A.
EUROPE

**UNITED STATES STEEL CORPORATION**—with a successful six-year experience using Permanente 165—adds another Permanente 165 bottom at #5 Open Hearth Shop, Homestead Works.

**EACH BATCH** of Permanente 165 Ramming Mix is checked for correct moisture content by a Kaiser Chemicals' Technician.

# U. S. STEEL INSTALLS

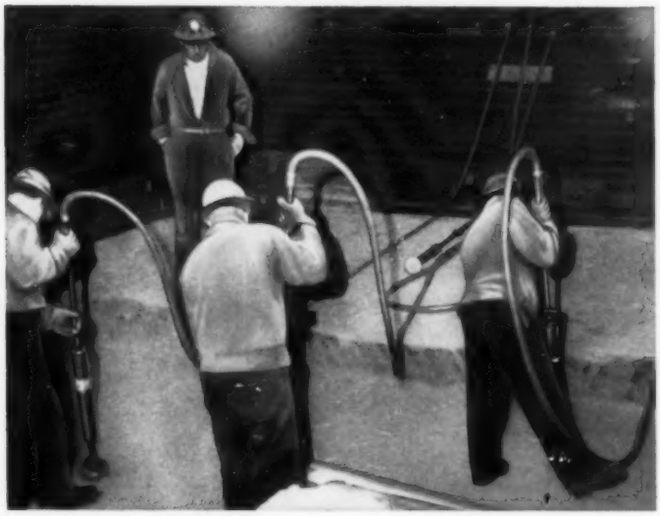
This Permanente 165 bottom is the 91st for United States Steel Corporation . . . and at #5 Open Hearth Shop, Homestead Works, it becomes the *tenth* furnace with a 165 bottom out of eleven furnaces on the line.

There is a good reason why U. S. Steel is using more and more 165 for furnace bottoms.

Experience has *proved* that it lasts significantly longer than other materials . . . that it requires fewer repairs and less down time . . . that it helps produce greater tonnage at lower bottom cost!

One of the reasons for this performance is Permanente 165's complete resistance to hydration under the most severe conditions. Another is its remarkable resistance to attack by iron oxide and slag. And still another is its installed high density—averages 175 lbs. per cubic foot *in the bottom where density means longer life.* Permanente

**RAMMERS COMPACT 165** against back wall as furnace bottom nears completion. When on line again, furnace will produce 300 tons of steel per heat.



**CAREFUL RAMMING** assures dense monolithic bottom after burn-in with more pounds of MgO per cubic foot (165 lbs.) than any other ramming mix.

**IN PRODUCTION** this new tap hole lasted 108 heats before repiping. Sub hearth shown here plus other portions of furnace were built of Kaiser Periclase Brick.

# ITS 91st PERMANENTE 165 BOTTOM

165 is made from high purity Kaiser Periclase refractory grains, 94-96% MgO. And because it ceramically bonds itself into a crystalline mass at relatively low temperatures, you get a tough, dense homogeneous bottom fast.

A new, completely revised 28-page manual, "Suggested Methods of Installing Permanente 165 and 84 Ramming Mixes," gives complete details. Send for your free copy.

Call or write Kaiser Chemicals Division, Dept. R7451, KAISER ALUMINUM & CHEMICAL SALES, INC., at any of the addresses listed below.

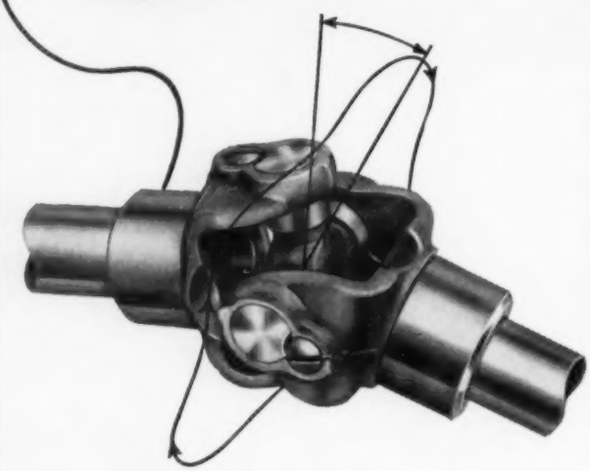
PITTSBURGH 22, PA. . . . . 3 Gateway Center
HAMMOND, IND. . . . . 518 Calumet Building
OAKLAND 12, CALIF. . . . . 1924 Broadway

# Kaiser Chemicals

**Pioneers in Modern Basic Refractories**

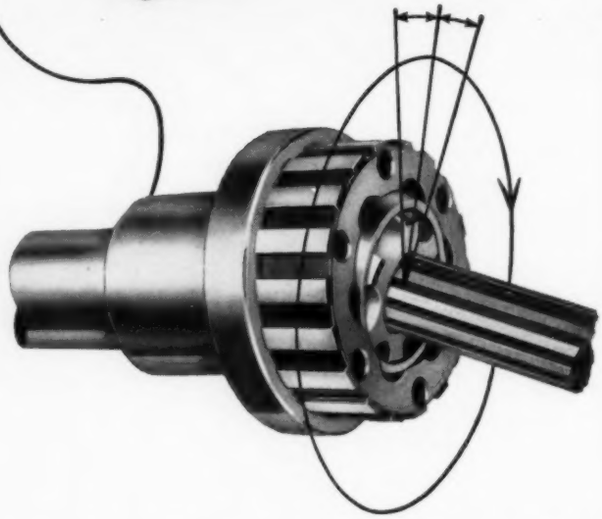
REFRACTORY BRICK & RAMMING MATERIALS • CASTABLES & MORTARS • MAGNESITE • PERICLASE • DEADBURNED DOLOMITE • ALUMINAS

THIS ACTION MAY HAVE A LOWER PRICE



Old-fashioned pin or slipper-type joints speed up, slow down twice during one revolution. This delivers rough "rock and roll" torque which results in greater vibration and wear. They must employ clumsy additional mechanisms to compensate for their unbalanced action at extreme angles.*

THIS ACTION ALWAYS HAS A LOWER COST



Rzeppa Joints *always* transmit smooth "full power" torque at angles as much as 35°! Ball bearings—located in a plane bisecting the angle between driving and driven members—deliver smooth rotation, eliminating wear and vibration. Constant velocity means longer joint and shaft life, too.*

57A

RZEPPA

SHEPPA

CONSTANT VELOCITY UNIVERSAL JOINTS

**The Gear Grinding Machine Company**

3929 CHRISTOPHER, DETROIT 11, MICHIGAN

MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES
DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES

*HOW RZEPPA'S CONSTANT VELOCITY SAVES YOU MONEY. If a universal joint operates with less friction it wears longer; if it has a higher capacity it can produce more. Through the principle of constant velocity—shown above—Rzeppa delivers these cost-savings that are impossible with designs of lower price.

Send us a dimensional sketch along with peak horsepower, operating angles and R.P.Ms. Our engineers will assist in making a proper joint recommendation. WRITE FOR LATEST BROCHURE.

# HOT-METAL CARS

# USS-DESIGNED

# to your specifications

As you know, industrial cars come in many different types and sizes. And the type and size you need can be designed and built to your specifications by United States Steel.

A typical USS-Designed Car is shown here. It's a 55-ton hot-metal car having a drop frame and trunnion stands for transporting a huge ladle of molten iron from the blast furnace to the mixer. Car is fabricated from all-welded, rolled steel, and is properly stress-relieved. Side frames are six-inch rolled-steel plate, and the huge trunnion stands are eight-inch steel plate.

This car is equipped with air brakes for use in trains; it also has power hand brakes. Other variations are available in hot-metal cars. For example, cars can be designed to carry two pots, and they can be built with air-operated tilting mechanisms.

For information on many types of industrial cars, send for a free copy of our 32-page illustrated booklet—"USS Custom Designed Cars." And remember, you can call our engineers for consultation at any time convenient to you.

- **WELDING THE HOT-METAL CAR.** Car is fabricated from rolled steel. It is all-welded and subsequently stress-relieved for extra-heavy duty.
- **READY FOR ACTIVE SERVICE.** This hot-metal car is designed with a drop frame and trunnion stands for transporting a huge ladle of molten iron from the blast furnace. Car has a 55-ton capacity, and is 9′ — 4″ wide x 26′ — 6″ long. Trucks are A.A.R. standard design and are for use on standard-gage track.

# USS INDUSTRIAL CARS

USS

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALABAMA
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

United States Steel Corporation
525 William Penn Place, Room 2801
Pittsburgh 30, Pennsylvania

Please send me a free copy of your 32-page booklet, "USS Custom Designed Cars."

Name .....

Company .....

Address .....

City ..... State .....

# Westinghouse mill motors with **silicone insulation**

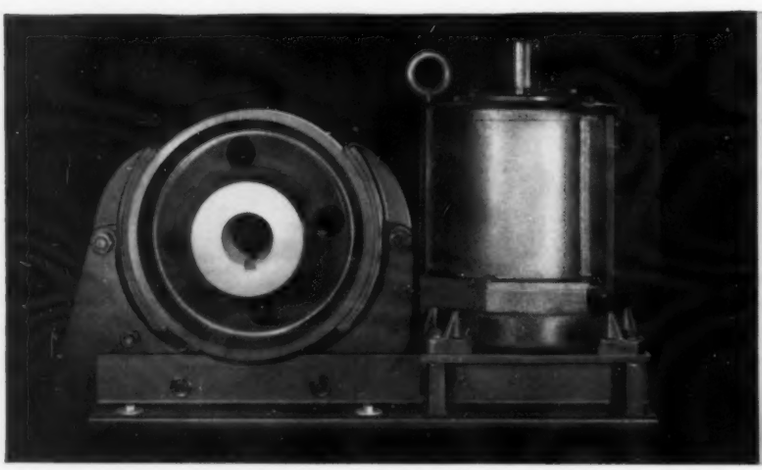
## *For longer motor life under the toughest operating conditions*

Silicone insulation for longer motor life . . . improved field coil design for greater capacity and cooler operation . . . heavy-duty shaft, bearing and housing design to take high torque loads . . . make the Westinghouse Hevi-Duty Mill Motor the most rugged package of power you can buy.

New silicone insulated armatures and the exclusive Westinghouse solid mass design with multi-dip finishing make it five times tougher for load surges to affect armature coils.

Maintenance is easy, too. New openings in lower frame give quick, easy access to commutator and brush rigging for inspection or repair. Silicone-insulated armatures and field coils are interchangeable with old-style units.

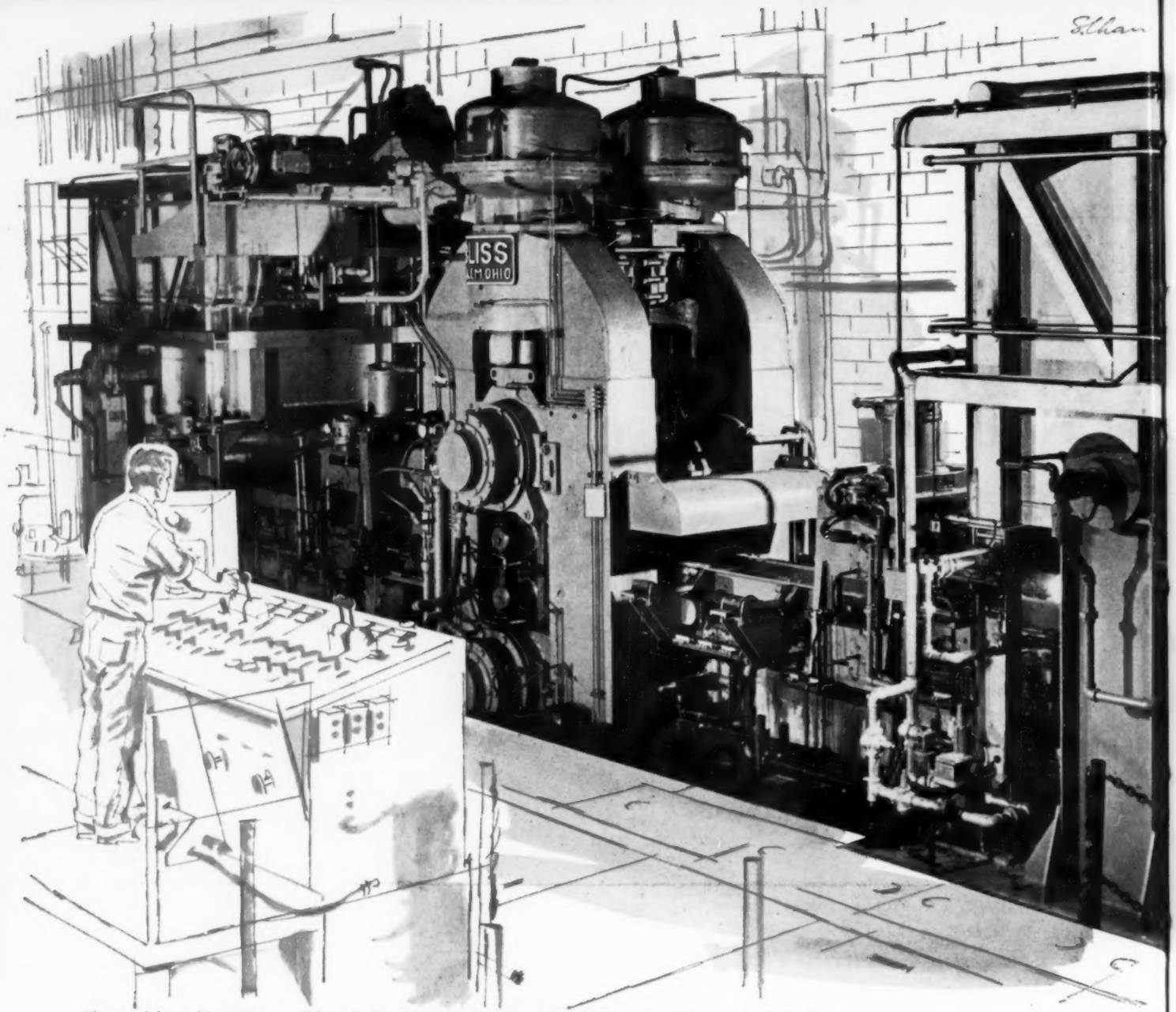
For complete information on the outstanding Westinghouse Hevi-Duty Mill Motor, call your Westinghouse sales engineer. Or, write Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania. Ask for B-6547. J-22049



**WESTINGHOUSE ALSO OFFERS:**
**The Only Self-Adjusting D-C Magnetic Brake**

When selecting mill motors remember that Westinghouse can furnish motors and brakes as one unit. Only Westinghouse D-C Magnetic Brakes are self-adjusting. This exclusive self-adjustment design means long brake life and minimum maintenance. For more information on the only Self-Adjusting D-C Magnetic Brake on the market ask for B-6548.

**YOU CAN BE SURE...IF IT'S Westinghouse**

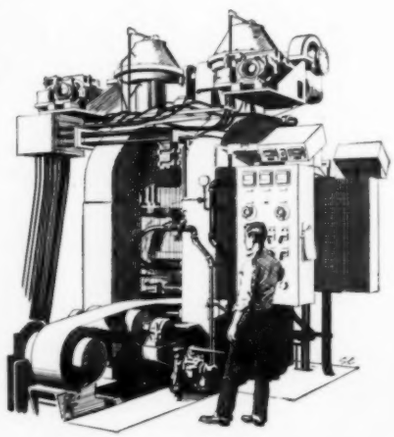



Blooms, slabs and hot strip can all be rolled in this triple-duty Bliss 4-high 15" & 32" x 24" reversing hot mill.

# U-235 or magnetic alloys, it's all the same to these Bliss mills

Among the key installations with which the new Westinghouse Metals Plant at Blairsville, Pa., explores the unknown in metalworking are two unusual Bliss rolling mills. Blairsville's business is finding ways to cast, roll, forge and otherwise fabricate new and experimental metals. The materials rolled range from uranium alloys to magnetic materials so sensitive that the pressure of a finger will alter their electrical properties. The Bliss mills and handling equipment combine precision of control with the ability to stand extremely heavy rolling stresses. Large enough to provide limited production output, they can take an alloy from ingot down to 0.010" cold-rolled strip.

Whether your plans call for highly specialized mills like these or standard rolling and mill processing equipment, Bliss can help solve your problem. For more information, send for a free copy of our 60-page Rolling Mill Brochure, Catalog 40-A.



Hot rolled strip is further reduced to gages as thin as 0.010" in this Bliss 4-high 8" & 28" x 24" reversing cold mill.

BLISS
SINCE 1857

*100 years of making metal work for mankind*

**E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio**

**Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio**

# Personnel News...

**William A. Cook** has been elected president of Phoenix Iron & Steel Co. Mr. Cook, who joined the company seventeen years ago, is a member of the board of directors of Phoenix Iron & Steel and is a vice president and board member of Phoenix Bridge Co. and of Barium Steel Corp., the parent company. In his new post he replaces **Rudolph Eberstadt.** Three other appointments were also announced: **John A. K. Sisto,** formerly an assistant treasurer, has been appointed vice president and executive assistant. **Daniel Eberstein,** secretary of the parent company, has been elected secretary. Mr. Cook joined Phoenix in 1940. He was appointed general sales manager in 1946 and a vice president in 1952. Prior to 1940, he was employed by Aluminum Co. of America for three years. **John Milos,** vice president in charge of operations for Phoenix Iron & Steel has been elected to the board of directors. He has also been elected a vice president and a director of Phoenix Bridge Co.

**Alfred E. Kadell,** formerly executive vice president of the Great Lakes Steel Corp. has been named project manager for the Argentine Steel plant being constructed by Arthur G. McKee & Co. Also **Henry E. Davis,** a retired Republic Steel Corp. superintendent in Buffalo and veteran of over 50 years in the steel industry, has been appointed chief of the inspection crew assigned to examine the components of a 66-in. strip mill, and to order replacements for defective and missing parts in preparation for erection of this facility. Mr. Kadell joined the Weirton Steel Co. in the fall of 1925 as assistant to the chief metallurgist. He moved up to assistant chief metallurgist, and then into operations as assistant manager and manager of the Tin Plate Division. In 1951 he was made general superintendent of Weirton Steel. In the summer of 1954 Mr. Kadell was transferred to the Great Lakes Steel Corp. as executive vice president. Mr. Davis, gained his experience from supervisory positions in electrical and maintenance departments with Republic Steel and predecessor companies for the past 45 years. In 1912 he was appointed chief electrician for the old Interstate Iron & Steel Co. Subsequently Interstate became a part of Republic Steel. In 1932, Mr. Davis was appointed superintendent of maintenance which included mechanical, electrical and building maintenance departments at the South Chicago plant and three years later he was transferred to Republic's Buffalo plant in a similar capacity.

**Eugene L. Kline** has been appointed assistant superintendent of the open hearth strip and bar mills and **Gabriel J. Erdos** has been made assistant superintendent of the butt and continuous weld tube mill at the Youngstown District, Republic Steel Corp. Mr. Kline joined Republic in Youngstown in 1934 as a weighmaster. He served as turn foreman, general foreman and assistant superintendent in the butt and continuous weld tube mills until taking over his new post. Mr. Erdos started with Republic as a foreman in Canton in 1945. He was transferred to the Youngstown District in 1947 and served as general foreman for five years in the galvanizing department and five years as general foreman in the finishing department of the butt and continuous weld tube mill before assuming his new duties.

**Arthur D. Bachtel** was appointed superintendent of the blooming and structural mills at Kaiser Steel Corp. Mr. Bachtel has been with the company since 1948, serving as assistant and acting superintendent in the same departments. From 1917 to 1933 he was employed in the open hearth and Bessemer departments of the Johnstown, Pa., works of Bethlehem Steel Corp., and from 1933 to 1948 at the Youngstown, Ohio, works of Republic Steel Corp., attaining the position of superintendent with each company.

**Stanley J. Miller** has been appointed assistant director, plant engineering division of Joseph T. Ryerson & Son, Inc. His headquarters are in the company's general offices in Chicago. Mr. Miller has been with Ryerson since 1941. He worked successively in the work order, plant engineering, and operating departments of the firm's Chicago plant. In 1949 he was appointed superintendent of the Ryerson steel service plant in Detroit. He returned to Chicago in 1954 as assistant operating superintendent, becoming warehouse superintendent the following year. For a short period in 1957 he served as plant engineer.

**Douglas R. Beggs,** former assistant to the vice president—production, The Carpenter Steel Co., has been appointed general superintendent of the Reading Pa.,

W. A. COOK

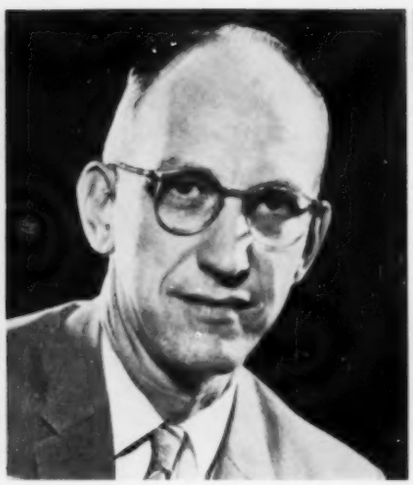
JOHN MILOS

A. E. KADELL

H. E. DAVIS

D. R. BEGGS

F. W. EVANS



H. W. MILLER

D. L. SPONSELLER

plant. **Foster W. Evans**, formerly superintendent of production control, has become production manager. **Harold W. Miller,** who continues as head of the company's Engineering Department, has been given the responsibility of coordinating all engineering functions including electrical and mechanical maintenance. Mr. Beggs joined Carpenter as a machinist apprentice in 1932, joined the Time Study Department in 1934, and advanced successively to time study engineer, head of time study, and director of personnel. He was appointed assistant to the vice president in 1954. Mr. Evans has been with the company since 1934 when he started as a clerk in the Preparation Department. He rose from that position to foreman in the hot mills, and to supervisor of hot mill scheduling and melting scheduling before he became superintendent of production control in 1947. Mr. Miller started his career with Carpenter as a chemist 20 years ago, and rose through the ranks as metallurgical assistant, assistant superintendent—Wire Department, superintendent of the Wire Department, and assistant general superintendent.

**David L. Sponseller** has been named superintendent of the Maintenance Department of the Hamilton, Ohio, plant of Armco Steel Corp. Mr. Sponseller joined Armco in 1929 as a draftsman in the Engineering Department. In 1939, he became a junior engineering draftsman and in 1942, he was promoted to mechanical engineer. He was later named assistant to the superintendent of maintenance, and was appointed assistant superintendent of maintenance in 1946.

**Andrew G. Forrest** has been named assistant to the chief metallurgist in the Cleveland general offices of Republic Steel Corp., Mr. Forrest, a veteran of 29 years' service with Republic, all spent at the company's South Chicago works, has been chief metallurgist there since 1941. He started in 1928, and was named assistant chief metallurgist in 1941.

**Harry J. McMahon** has been appointed assistant to the general manager of the Yorkville, Ohio, Works of Wheeling Steel Corp. He has been with Wheeling since 1930, starting as a clerk at the Beech Bottom, W. Va., Works. He was transferred to the Benwood, W. Va., Works in 1950 as supervisor of personnel. In 1954 he was promoted to the position of assistant to the general manager, Wheeling factory, and since August of last year had been assistant to the general manager at the Martins Ferry plant. **James R. McCleery,** has been promoted to the position of assistant to the general manager, Martins Ferry factory. He is a 32-year Wheeling Steel veteran, having become associated with the company in a clerical capacity at the Yorkville Works in 1925. After serving in various clerical positions at the Yorkville and Martins Ferry plants, he was appointed personnel supervisor of the Martins Ferry Factory in 1942, which position he retained until his recent promotion.

**O. O. Royer** was promoted to assistant general sales manager of Parker Appliance Co. He was manager of sales statistics and marketing research from 1950 to 1956, when he was made marketing manager.

**Harvey B. Wilgus** has been elected to the position of vice president in charge of sales for the Electric Products Co. Mr. Wilgus has been general sales manager since joining the company in 1955.

**Albert L. Hunt** and **Paul J. Bauman** were appointed vice-presidents of the National Bearing Division of American Brake Shoe Co. Mr. Hunt was formerly general manager of the division's St. Louis plant, responsible for all operations and industrial sales for the plant. In his new capacity he will be in charge of all manufacturing operations for the division's plants in St. Louis, Meadville, Pa., and Clearing, Chicago. With Brake Shoe since 1936, Mr. Hunt became general manager in 1956. He will continue to be located at division headquarters in St. Louis. Mr. Bauman was formerly general manager of National Bearing's plant in Meadville. He was responsible for the sales and operations of the plant. In his new capacity as vice-president, he will be responsible for the industrial sales of the entire National Bearing Division. With Brake Shoe since 1938, he will continue to be located in Pittsburgh.

**Jay W. Picking** was appointed manager of the Control Division of Reliance Electric and Engineering Co., and **Earl C. Barnes** was named chief engineer. **Karl H. Meyer**

# They look like twins... but one is synchronous

**Louis Allis "SYNCRO-*SPEDE*"* offers... for the first time... a synchronous motor in the same frame sizes as a standard induction motor**

New from Louis Allis — *the most compact and efficient synchronous induction motor on the market* ... the revolutionary "Syncro-Spede." It's the *only* synchronous motor built in standard NEMA frames for comparable ratings in any enclosure.

The space-saving "Syncro-Spede" has no external excitation, wound rotating fields, collector rings or brushes—offers simplified control and low-cost operation. And it's virtually maintenance-free.

In performance, "Syncro-Spede" delivers and maintains exact synchronous speed within its rated capacity, regardless of load variations or voltage dips. When "Syncro-Spede" motors of several different ratings are powered by a single adjustable-frequency source, their acceleration, running speed, and deceleration can be synchronized.

"Syncro-Spede" is the low-cost answer to such demanding synchronous applications as *precise adjustable-frequency multi-motor systems*... high-frequency generator drives and constant-speed conveyor drives . . . precision timing and metering devices . . . recording instrument drives . . . any system requiring constant speeds from no-load to full-load.

"Syncro-Spede" sizes range up to 100 hp. For information and expert application engineering assistance, contact your nearby Louis Allis District Office or write directly to The Louis Allis Company, 450 East Stewart Street, Milwaukee 1, Wisconsin.

*"Syncro-Spede" is a trademark of the Louis Allis Co.

**LOUIS ALLIS**

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

**The 500th** Treadwell mixer-type hot-metal car was recently shipped to California on its own wheels.

# TREADWELL RECORD!

## 500 mixer-type hot-metal cars since 1916

It has been forty years since M. H. Treadwell Company pioneered the production of mixer-type hot-metal cars. Since that time, 500 cars have been placed in service. Of this number, over 95% are still in use—in almost all of the major iron and steel plants in the United States and Canada.

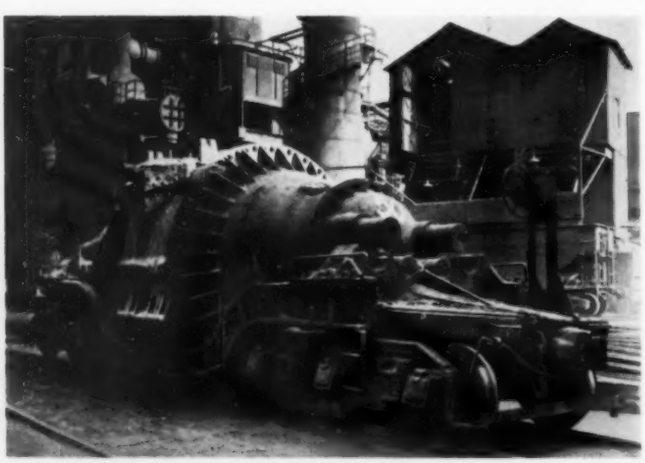
A survey made in 1950, disclosed that Treadwell cars were handling 51% of the combined production of the two countries, exclusive of ferro manganese and the output of smaller blast furnaces. In this same year, Treadwell introduced the 200-ton capacity mixer-type car.

Drawing on this matchless experience, Treadwell can build any kind of mixer-type hot-metal car required in today's plants. Ranging in capacity from 75 to 200 net tons, cars are equipped with a motor-operated dumping device and a hand mechanism for rotating the ladle in case of power failure. Truck journals can be fitted with friction or anti-friction bearings.

Next time you're in the market for hot-metal cars, remember the Treadwell record. Meanwhile, send for bulletin 60.

**M. H. TREADWELL COMPANY, INC.**
140 Cedar Street, New York 6, N. Y.
1015 Farmers Bank Bldg., Pittsburgh 22, Pa.
208 So. La Salle St., Chicago 4, Ill.

**TREADWELL**
Mixer-type
HOT-METAL CARS



***The first*** Treadwell mixer-type hot-metal car, which was built in 1916, is still in operation.

TR-25

was named manager-manufacturing services and **Jonathan L. Collens** was named assistant division manager of the Ivanhoe Division. **Don E. Bouffard** was promoted to manufacturing manager of the Ashtabula Division, and **Ralph G. Davis** was named assistant division manager.

**Jesse P. Johnston** has been appointed combustion engineer of the Middletown Works' Engineering Department of Armco Steel Corp. Prior to his promotion, Mr. Johnston was assistant combustion engineer.

**Bruce M. Shields** was named chief metallurgist at Duquesne works, U. S. Steel Corp. At the same time **Wilber J. Ballantyne, Jr.,** was named assistant to general superintendent, and **Robert J. Loose,** assistant superintendent, production planning department. Mr. Shields started at Duquesne in 1951 as general supervisor, development and research and later that year became chief development metallurgist. In March, 1954, he became chief process metallurgist and in 1956 was made assistant chief metallurgist. On April 1, 1957, he became assistant to the general superintendent at Duquesne, the position he held until his recent appointment. Mr. Ballantyne began his career with U. S. Steel in 1942 as a practice apprentice, industrial relations department. In 1943 he was made metallurgical observer in the open hearth, and in 1945 became general turn foreman in the metallurgical department. In 1947 he became special engineer in the merchant mills and in 1948 became general turn foreman, No. 5 merchant mills. In 1954 he became general foreman No. 6 and 7 mills, and in 1956 he was made assistant superintendent, merchant mills at Duquesne, the position he held until his recent appointment. Mr. Loose began with U. S. Steel in 1941 at the Farrell Works as an industrial engineer. In 1948 he became general supervisor, methods in the industrial engineering department at Duquesne Works, where he worked until 1953 when he was promoted to assistant plant engineer, the position he held until his recent appointment.

**Samuel A. Garee** has been appointed manager of operations for The Gas Machinery Co. Mr. Garee came to Gas Machinery from Gas Atmospheres, Inc., where he was general manager. Before that, he was chief engineer and assistant manager of engineering of the Lee Wilson Contracting Co. and was superintendent of construction of the Steel and Tube Division of Timken Roller Bearing Co.

**Robert R. Bowman** was named district sales manager of the Buffalo sales area for Harbison-Walker Refractories Co. He had been a sales representative in the company's Buffalo office for the past five years.

**Ralph A. Petersen** has been appointed manager of the new Birmingham, Ala., district office of Pangborn Corp. Mr. Petersen recently joined Pangborn as a sales engineer assigned to the home office in Hagerstown, Md. He now has the states of Alabama and Mississippi and eastern Tennessee as his territory.

**Stanley C. Killian** has been named a vice president of the Delta-Star Electric Division, H. K. Porter Co., Inc. Mr. Killian, became chief engineer of Delta-Star in 1944 and assistant general manager in 1954.

**Arthur W. Storm** has been appointed chief engineer of the new Pelletizing Division of Surface Combustion Corp. For the past two years he was supervising engineer in charge of designing, estimating, analyzing and scheduling for the Erie Mining Co. taconite agglomerating project.

**Robert W. Leech** was named vice president in charge of heavy steel mill engineering sales, Auburn & Associates, Inc. Mr. Leech comes to the company after completing a career as area sales manager in the Pittsburgh office of Westinghouse Electric Corp. Also, **William B. Kennedy** has been appointed assistant vice president in charge of the civil engineering department of the company, and **Carl W. Oettinger,** has been appointed chief electrical engineer.

**J. R. Miller** has been elected as chairman of the board and executive vice president of Ramseyer & Miller, Inc.

**H. W. Cory** was named assistant manager of the control department, and **W. F. Eagan** was named as engineer-in-charge of control engineering of Allis-Chalmers Manufacturing Co. Mr. Cory has been associated

J. P. JOHNSTON

B. M. SHIELDS

W. J. BALLANTYNE, JR.

R. J. LOOSE

W. R. HOUGH

W. H. HABER

H. D. LUKE

R. A. GEUDER

with the firm's control operations since 1941 and had been chief engineer in the department since 1955. Mr. Eagan had been supervisory engineer of regulator engineering and circuit development in the department since 1955. He joined the firm in 1947.

**William R. Hough, Walter H. Haber,** and **Hugh D. Luke** were elected vice presidents—operations of Reliance Electric & Engineering Co. At the same time, **Richard A. Geuder** was elected vice president—marketing. These are new offices, created in line with the company's policy and concept of operating by divisional groups. Mr. Hough, who is also vice president—engineering, joined Reliance in 1929. Mr. Haber, who is Ashtabula division manager, started with the company in 1930. Mr. Luke, the Ivanhoe division manager, came into the company's manufacturing organization in 1953. Mr. Geuder joined Reliance in 1929 and was named general manager—marketing earlier this year.

**Charles C. Eppley,** has been named division superintendent, maintenance, Ohio Works, U. S. Steel Corp. He succeeds **H. R. Gravenstreter,** who is retiring. Mr. Eppley was formerly assistant division superintendent, maintenance. **Walter W. Bentz** was appointed assistant division superintendent, maintenance. He was formerly superintendent, maintenance shops, McDonald Mills. **George R. Grishkat, Jr.,** replaces Mr. Bentz as superintendent, maintenance shops, McDonald Mills. Other Youngstown District appointments announced were **John D. Carr** as assistant superintendent, No. 18 mill, McDonald Mills; **William H. Kirwan** as superintendent, 43-in. mill, Ohio Works; and **Calvin E. Keppler,** superintendent, 40-in. rolling mill, Ohio Works.

**George H. Dremann** has been appointed chief engineer of Moffett Engineering Inc. Mr. Dremann comes to Moffett from Bedford Foundry & Machine Co., where he was assistant chief engineer.

**George R. Ziegler** has been appointed general superintendent of the Chicago Heights, Ill., plant of the Inland Steel Co. He succeeds **W. Porter Goodman** who retired after 39 years with the company. Mr. Ziegler, formerly assistant general superintendent, has been with the company since 1939.

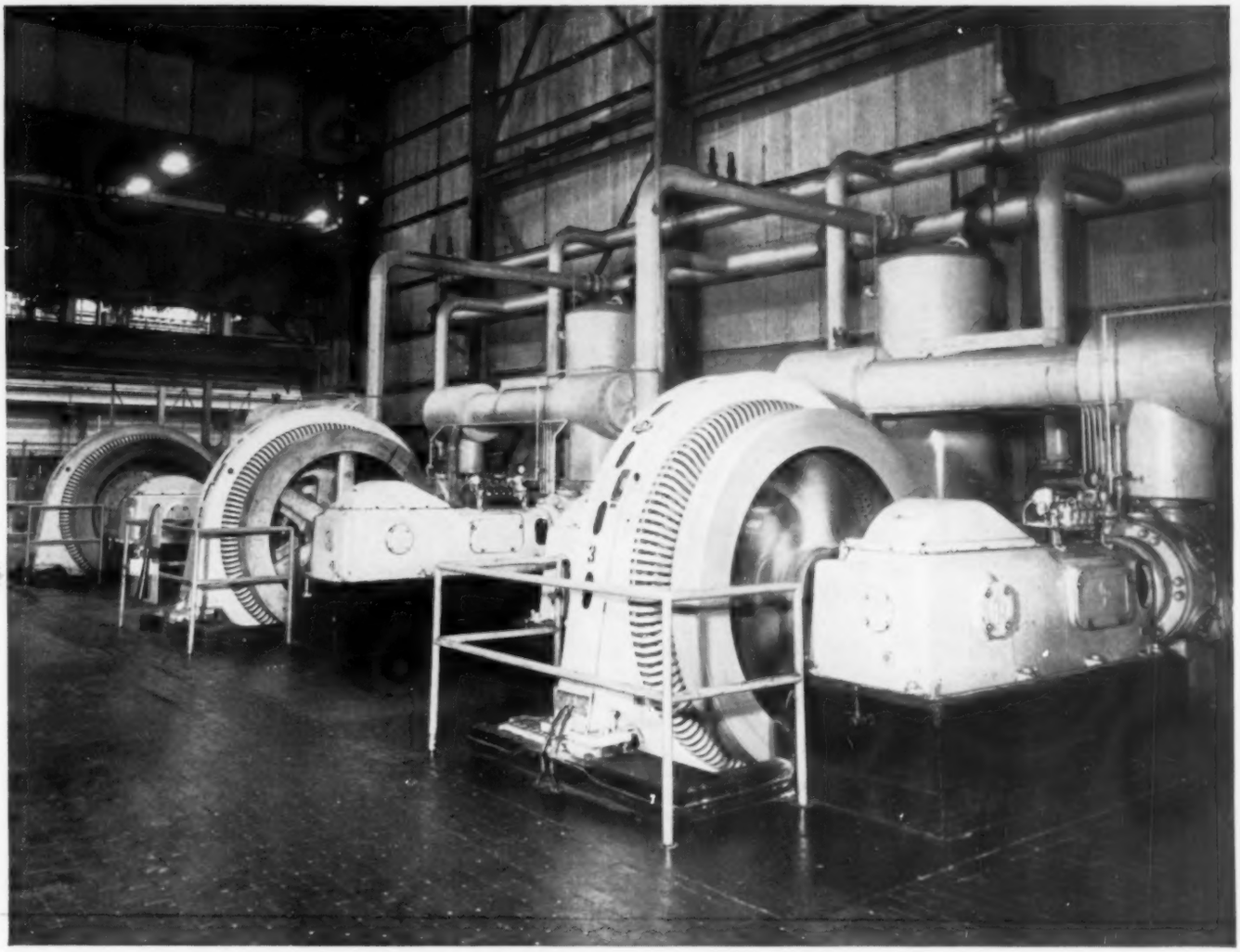
**Carl O. Knierim** has been appointed manager of heat treat sales for The Gas Machinery Co. Associated with Gas Machinery for 16 years, Mr. Knierim was most recently chief engineer for the Industrial Furnace Divi-

C. C. EPPLEY

W. W. BENTZ

W. H. KIRWAN

C. E. KEPPLER



Above are three 500 hp, 225 rpm, 2300 volt, 0.8 power factor E-M Synchronous Motors driving air compressors in the tin finishing department at the new Fairless Works of United States Steel Corporation. Three other 500 hp and five 300 hp E-M Motors also drive air compressors, in the hot strip and slab mill, central power station, open hearth pumphouse and sulfate building of the coke works.

# Power costs held low on compressor drives at new Fairless Works

Supplying air for controls, tools, handling systems and maintenance equipment is vital business at Fairless Works. And cost of power for operation of the air compressors is an item to be watched in such a large mill.

That's exactly where the E-M Synchronous Motors fit in. They help contribute real economy and rugged reliability to compressor operation.

**First of all,** these 11 E-M Motors are capable of supplying approximately 2700 reactive kva to improve plant power factor, a significant element when you want to minimize power costs.

**Secondly,** the inherent high efficiency of E-M Synchronous Motors utilizes power most sparingly.

Other economies are accomplished by use of simple and low-cost full-voltage control for across-the-line starting. Maintenance economy is foretold by simplicity of E-M Synchronous Motor direct-connection . . . by extra strong lashing of E-M stator coils . . . by the high capacity of E-M cage windings to withstand repeated starting stresses.

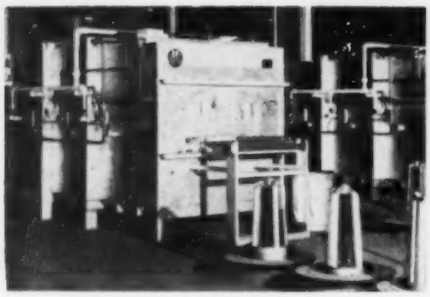
To get top performance from your large compressor drives, discuss your needs with your nearest E-M sales engineer. And write factory for E-M Synchronizer No. 32, a special issue on air compressor drive applications.

**ELECTRIC MACHINERY MFG. COMPANY**
**MINNEAPOLIS 13, MINNESOTA**

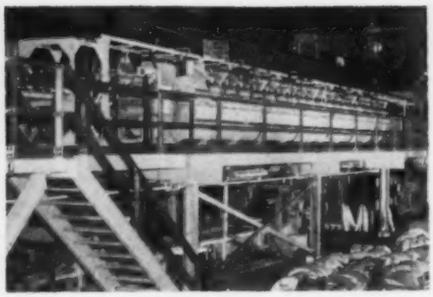
E-M

1200-TPA-2168

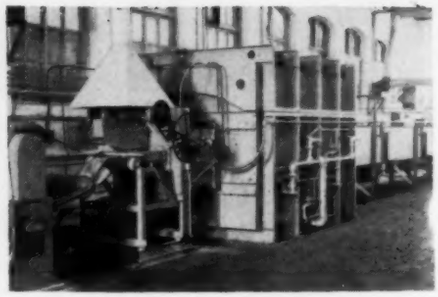
*Specialists in making motors do*
**EXACTLY WHAT YOU WANT THEM TO**



An EF multiple tube type furnace bright annealing stainless steel wire, continuously. One of an installation of five stainless steel furnaces we built in a prominent steel plant.



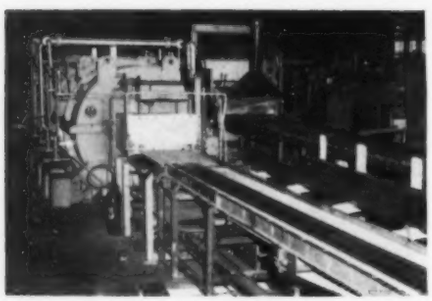
Large capacity EF gas fired furnace bright annealing stainless strip. We build them electrically heated or gas fired for wide or narrow strip, for single or multiple strands.



Stainless steel strip in various widths is bright annealed continuously in this EF gas fired special atmosphere installation equipped with an EF gas fired ammonia dissociator.

# Bright Annealing Stainless

## Tubing, Strip, Wire, Stampings and Other Stainless Steel Products



Stainless Steel Tubing in various diameters and lengths up to 24 feet is bright annealed continuously in this EF gas fired furnace.

Stainless Steel Strip. Wide, narrow and in various types, is uniformly bright annealed, continuously, in EF furnaces — any tonnage.

Stainless steel strip, wire, heavy and fine tubing, stampings, flatware, cooking ware, drawn and other stainless steel products, in many shapes and forms, are being bright annealed, uniformly, economically, continuously and with laboratory precision in EF furnaces of various sizes and types we have built.

Extensive experience with stainless steel problems, backed by over 40 years of practical furnace building experience and thousands of successful fuel fired and electric installations, enable EF engineers to design and build the best size and type of equipment needed for handling any product or production, or for any heat processing requirement.

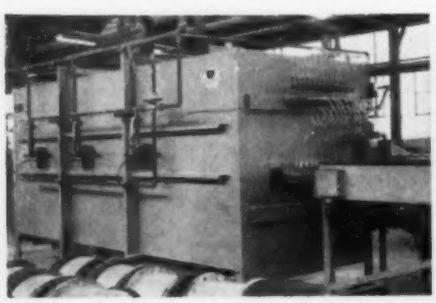
**Submit your production furnace problems to experienced EF engineers — it pays.**

**THE ELECTRIC FURNACE CO.**

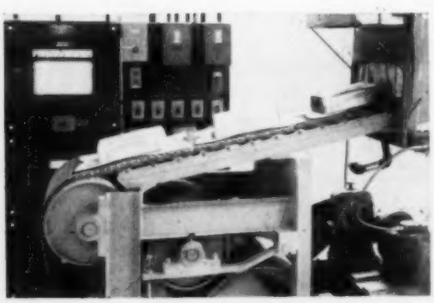
GAS FIRED OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

*Salem - Ohio*

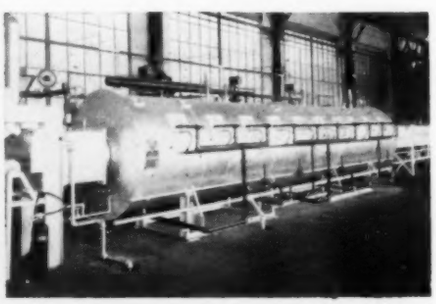
**Canadian Associates • Canefco Limited • Toronto 1, Canada**



Stainless Steel Wire is bright annealed in this and other EF continuous and batch type gas fired and electric furnaces we build.



Stainless Steel Stampings, flatware, drawn and other products; large, small and in various shapes are bright annealed in EF furnaces



Another type we build for bright annealing stainless strip. This EF furnace also handles other grades requiring lower temperatures.

sion. **H. A. Anderson,** formerly a sales engineer in the furnace division, was promoted to chief project engineer.

**R. M. Richardson** who was formerly manager, advertising and sales promotion of the Ramtite Co., has been transferred to the company's Pittsburgh office where he will serve in the capacity of sales and advertising consultant. **David Hefter** has been named to succeed him as advertising manager.

**Claude E. Christie** and **William D. Raddatz** have been appointed vice presidents of the Electro-Alloys Division of American Brake Shoe Co. Mr. Christie, works manager of the division's plant at Elyria, Ohio, has been with the company since 1923. He started as plant engineer and continued until 1935 when he was promoted to finishing superintendent. He was appointed general superintendent in 1947 and works manager in 1953. In his new position as vice-president, Mr. Christie will continue to act as works manager. Mr. Raddatz, sales manager of the divison, has been with the company since 1937. He started with the firm as assistant metallurgist at the American Manganese Steel Division. In 1938 he became production manager and in 1940 sales engineer. He was promoted to sales manager in 1955. As vice-president he will continue to perform the duties of sales manager.

**Robert L. Reed** has been appointed regional manager of the Pittsburgh sales region for Electro Metallurgical Co. Prior to his new appointment, Mr. Reed was acting regional manager of the Pittsburgh region, which includes the Pittsburgh and Cleveland districts. Mr. Reed previously served as a metallurgist for United States Steel Corp. and General Motors Corp. He joined Electromet in Chicago in 1946 and was named manager of the Detroit district in 1953 and of the Pittsburgh district in 1954.

**George J. Siener** has been appointed assistant to the superintendent of mechanical maintenance at the Buffalo, N. Y., plant of Republic Steel Corp. Mr. Siener joined Republic in 1949. He was promoted to field engineer in 1953, the position he held at the time of his current advancement.

**H. Lindley Hosford** has been named district manager of The Okonite Co.'s Philadelphia, Pa., office, succeeding **J. G. Wicks,** now regional sales manager of the electric wire and cable organization. Mr. Hosford was formerly manager of Okonite's Rochester, N. Y., office.

**George D. Klump** has been named manager—manufacturing engineering for General Electric Co.'s Small Steam Turbine Department. Mr. Klump joined General Electric in 1923 on the apprentice training program at the company's Schenectady Works. In 1940 he was named a foreman at the Schenectady location, and two years later was appointed general foreman at the Fitchburg Works. He was appointed manufacturing administration specialist in 1953, and in 1955 directed the organization of an apprentice training program at the Small Steam Turbine Department.

## *Obituaries*

**John R. Chegwidden,** 54, assistant superintendent of Bethlehem Steel Corp.'s Saucon Div., at Bethlehem, Pa., died July 28. Mr. Chegwidden had been with Bethlehem for the last 29 years.

**George P. Williamson,** electrical engineer, who had been associated with the Crocker-Wheeler Division of Elliott Co. for 50 years, died July 8. Mr. Williamson entered the employ of the Crocker-Wheeler Co. in 1907, and was active until about two years ago, when he assumed the status of consultant. He was an outstanding authority in the field of direct-current motor and generator design, and was particularly active in the design of the AISE Mill Motor.


**Call or Write STAMCO for...**

Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

**STAMCO, Inc., New Bremen, Ohio**

FERROFILTER®

**Permanent Magnet Separators**

Save wear on roll neck bearings and other vital contact points by extracting ferrous grit—rust, steel particles worn off equipment, core sand, etc.—from lines circulating lubricating oil in heavy mill equipment.

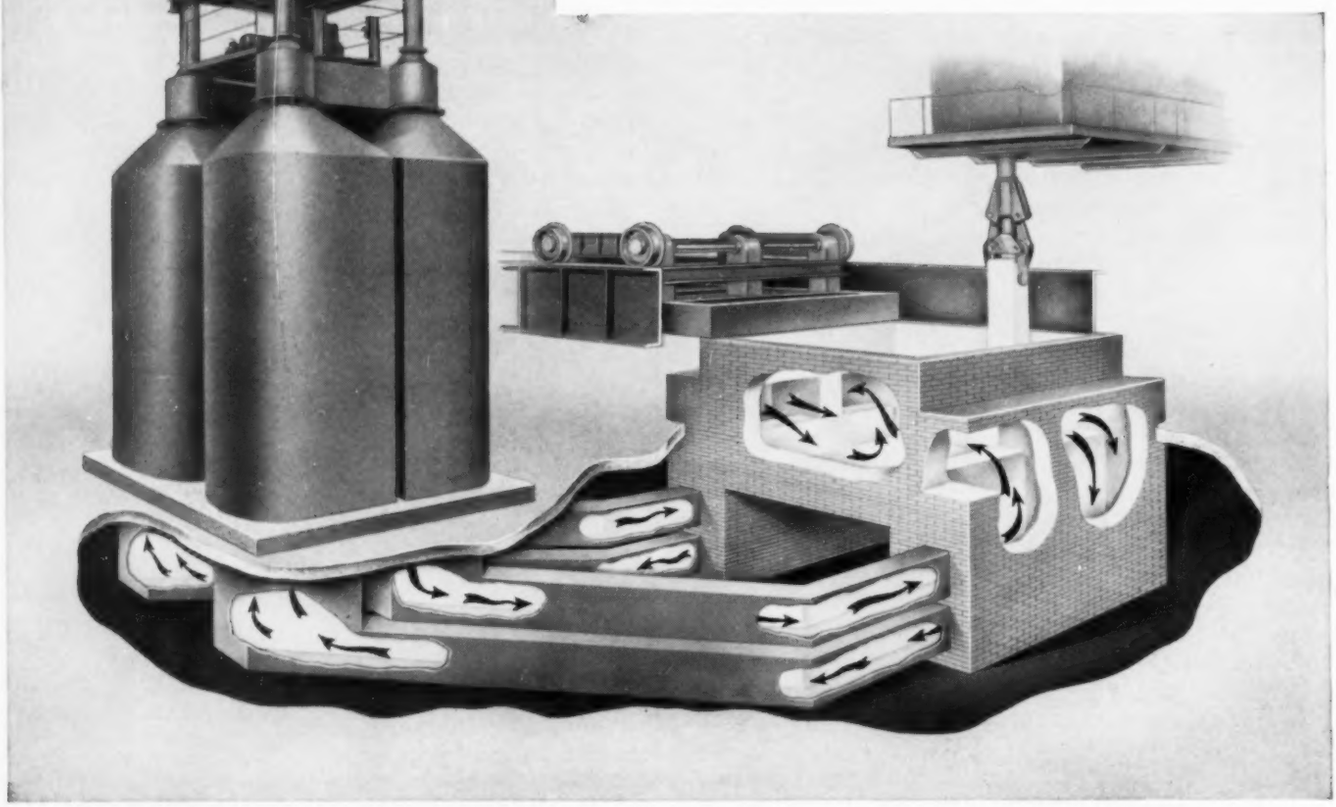
Model PQ-6 for 3" pipe line available with screwed or flanged connections. Other sizes from ¾" to 8".

Send for BULLETIN PM-44

**S. G. FRANTZ CO., Inc.**
Brunswick Pike and Kline Ave.
P. O. Box 1138 Trenton 6, N. J.

# HEAT MORE STEEL with MORGAN-ISLEY

The Morgan-Isley system offers you a better means of heating ingots with straight blast furnace gas, coke oven gas, natural gas or oil.



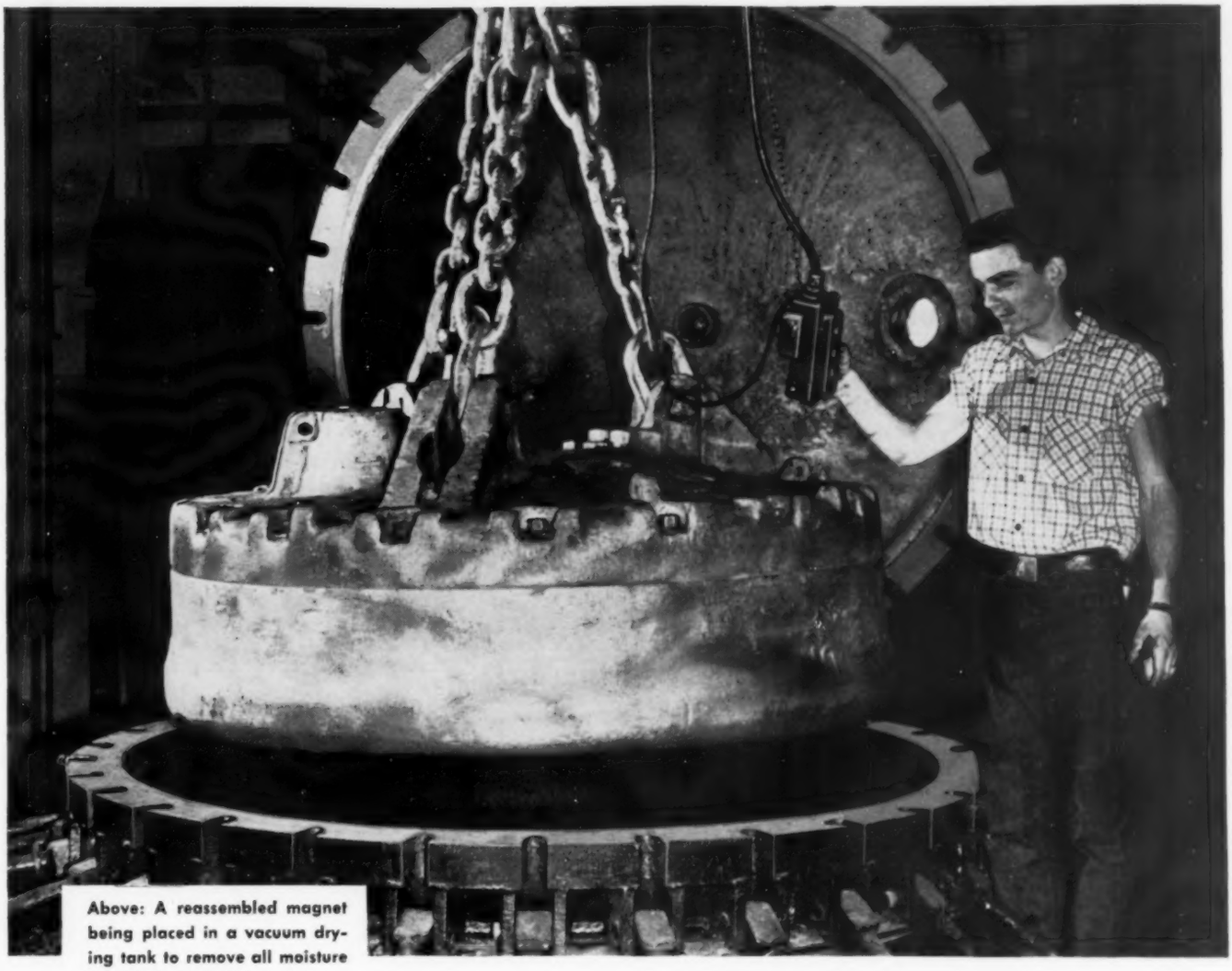
The schematic shows the flow of combustion air and flue gases through the regenerators and soaking pit. The Morgan-Isley system employs vertical regenerators. It eliminates regenerator capacity under the crane runway thus freeing this valuable area for heating steel.

CCC-69

**MORGAN CONSTRUCTION COMPANY** WORCESTER, MASS.

ROLLING MILLS • MORGOIL BEARINGS • REGENERATIVE FURNACE CONTROLS • EJECTORS • PRODUCER GAS MACHINES

H.H. Wood, Representative, Koppers Building, Pittsburgh, Pennsylvania



Above: A reassembled magnet being placed in a vacuum drying tank to remove all moisture before compounding.

Below: Magnet case being opened on a large capacity boring mill. Capsule-type magnet coils must also be opened by cutting on this mill.

# NATIONAL

## is equipped for high speed, high quality

# Lifting Magnet Repairs

**National's lifting magnet department has the equipment, manpower and the "know-how" to restore your lifting magnets to original specifications — and to improve them by redesign which takes full advantage of recently developed techniques and materials. And the new, modern equipment in this department not only insures high quality but speeds production.**

**For details on what these facilities can mean to you, just call your nearby National field engineer or drop us a line.**

## NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION— REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

# Morgan Engineering Co.

## ...at the vital spots maintaining continuous,

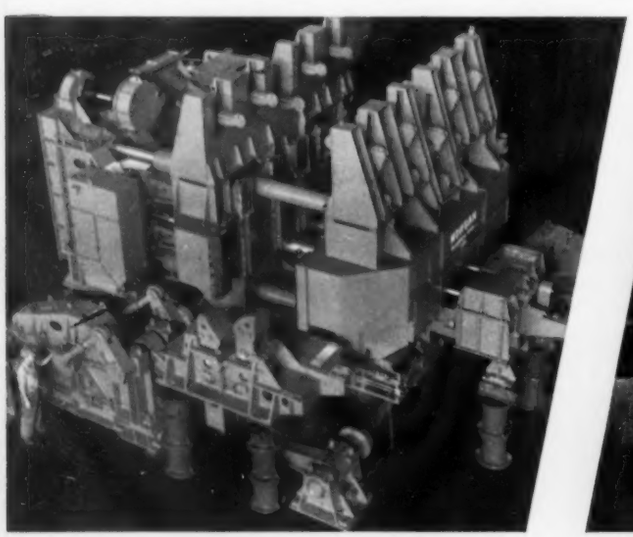
Wherever steel is made, huge blocks of metal are worked or great weights must be lifted, you find the nameplate . . . "Morgan—Alliance, Ohio—USA"... famous for advanced design in cranes since 1878.

Today, through years of far-sighted research and sound engineering, many other types of Morgan mill equipment are equally well known. Mills, roller tables, shears, saws, presses and auxiliary equipment built by Morgan offer the same fine performance standards.

New speeds and efficiency, greater capacities, lower operating and maintenance costs are characteristic of all Morgan-built equipment. Each design advance reflects close contact with your requirements . . . and Morgan Engineering Company's unusual talent for anticipating and

**FREE REPRODUCTION**—*A 14" x 20" reproduction of this 1888 Morgan Engineering drawing is available for framing. Kindly mail request on company letterhead.*

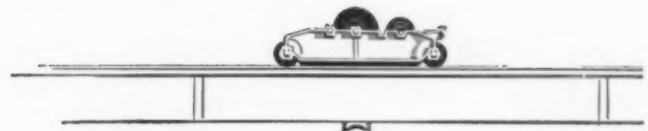
**TODAY** *you find the name "Morgan" on all types of mill equipment . . . handling the big jobs and the tough ones. Shown below: open hearth charging machine and gag straightener for 36" beams.*



# lower cost production

solving problems of the fast-growing metals industry.

Quality craftsmanship in every detail is a tradition that pays off in efficient, uninterrupted production in your mill operations. Let our representative show *you* how to speed production and lower costs with Morgan mill equipment.



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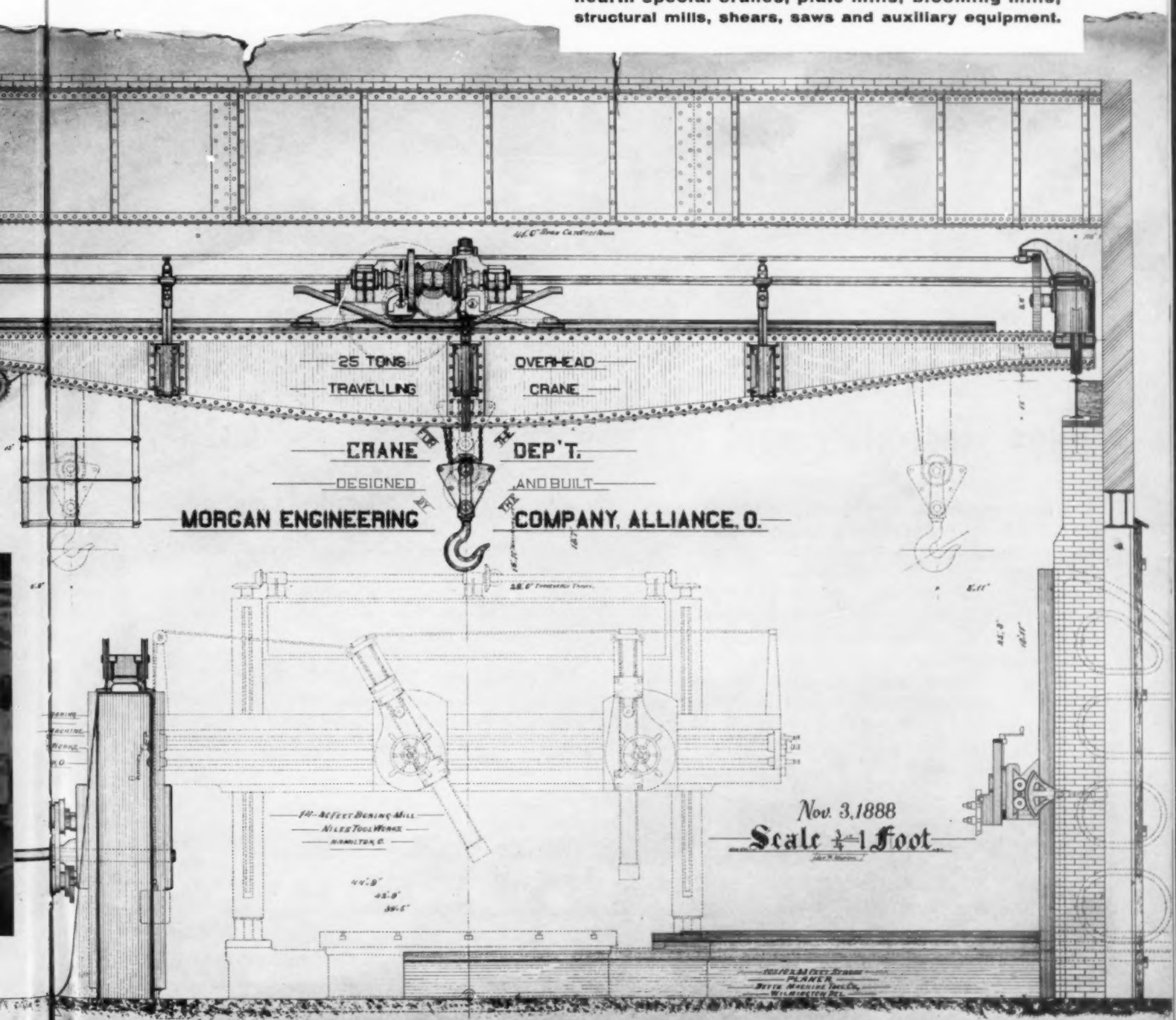
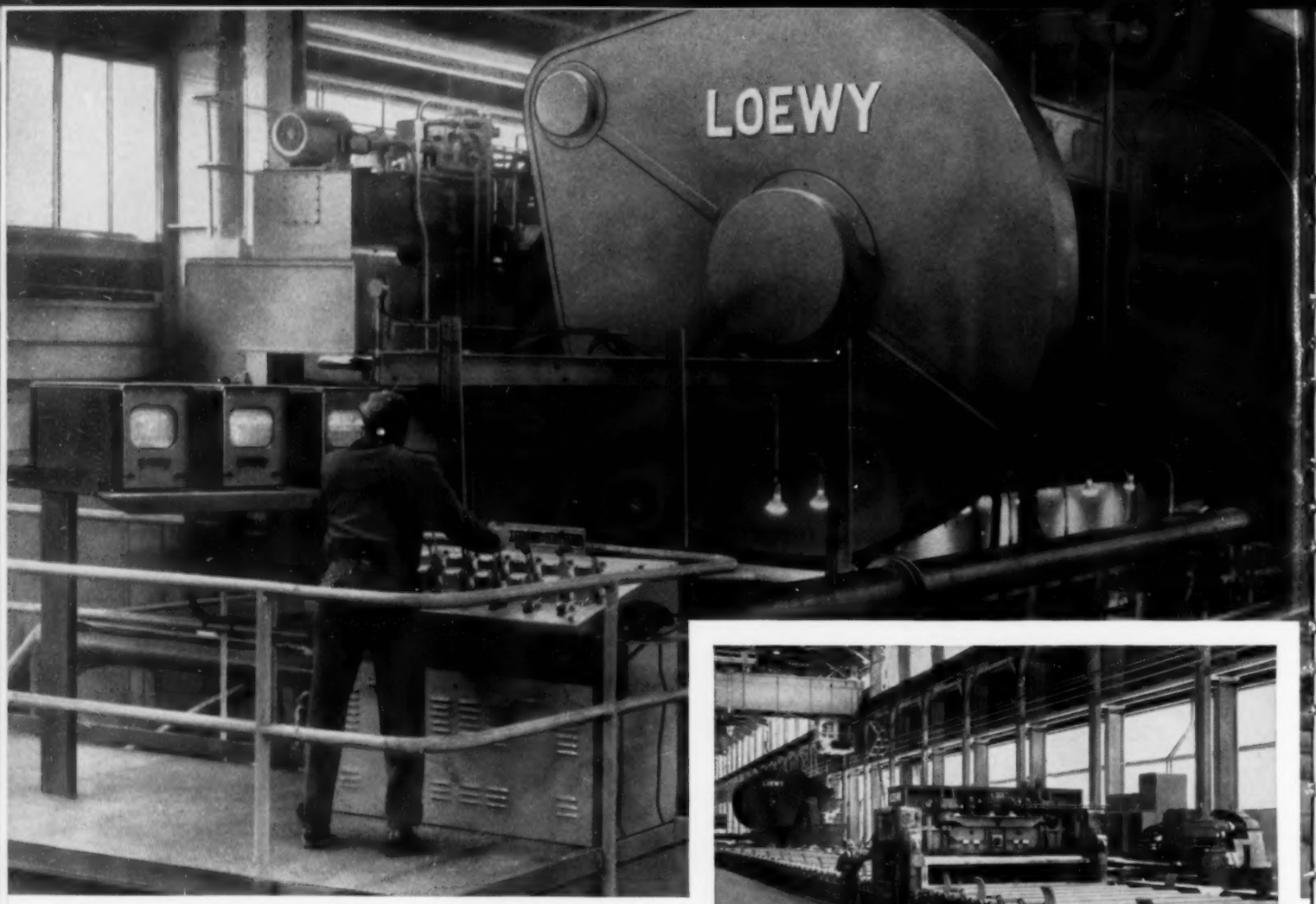
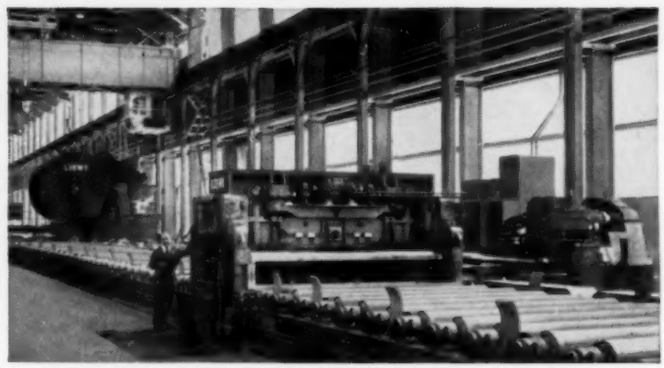
MORGAN
ENGINEERING CO. *Alliance, Ohio*

**Overhead electric traveling cranes, gantry cranes, open hearth special cranes, plate mills, blooming mills, structural mills, shears, saws and auxiliary equipment.**




Loewy-Hydropress alloy steel plate shear with completely mechanized, one-man-operated plate manipulator at the Lukens Steel heat treating plant, Coatesville, Pa.



Loewy designed and built shearing and leveling line at Lukens Steel.

# At Lukens Steel . . . one-man-controlled alloy steel plate heat treating and shearing installation

The 800-ton-capacity alloy steel plate shear shown above is part of a complete Loewy-Hydropress shearing-leveling and mechanized plate-handling installation at Lukens Steel's Coatesville plant, considered the most modern alloy steel plate heat treating facility in the United States.

By means of a specially developed plate manipulator —a truly mechanized handling system—the need for manual plate handling has been eliminated. One shear performs all cutting operations in succession. It is capable of cutting up to 1¼-in.-thick alloy steel plate. All movements for cutting four sides of the plate are remote-controlled by one operator who moves it into the shear, lines it up with the aid of a TV circuit, and then accurately cuts it to size.

This Loewy-Hydropress installation is another outstanding example of the advanced auxiliary equipment so vital to a really integrated mill operation.

Loewy-Hydropress, builder of all types of rolling mills, also designs and builds roller-straighteners, levelers, manipulators, individually driven motor rollers, ingot pushers and tilters, transfer tables, mechanical cooling beds, and other auxiliary equipment to the customer's individual requirements. The vast, integrated facilities of Baldwin-Lima-Hamilton enable Loewy to speed the delivery of this equipment.

Write us today, Dept. C-8 for further information.

**Loewy-Hydropress Division**

**BALDWIN · LIMA · HAMILTON**

111 FIFTH AVENUE, NEW YORK 3, N.Y. Rolling mills • Hydraulic machinery • Industrial engineering

BALDWIN BLH LIMA-HAMILTON

If you flew into
Ft. Worth tonight...

Your landing would be lighted with power from the world's

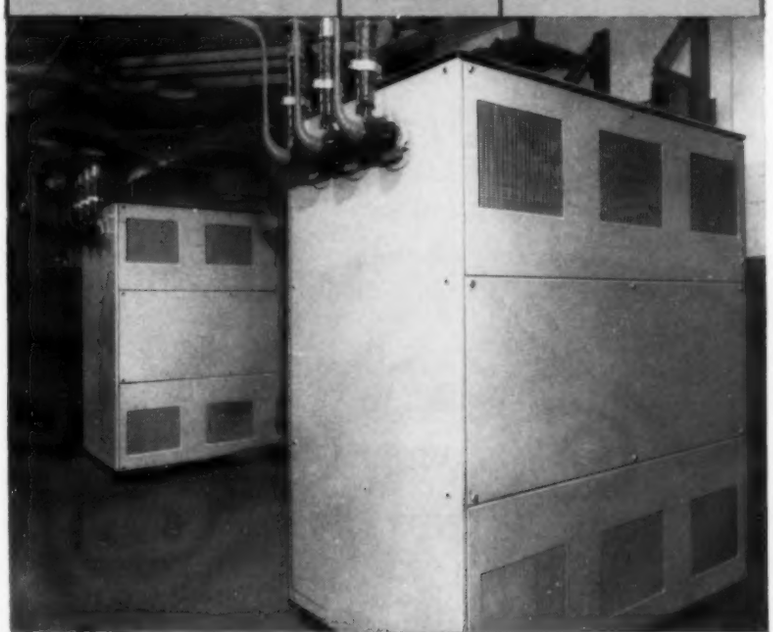
# SAFEST DRY-TYPE TRANSFORMERS

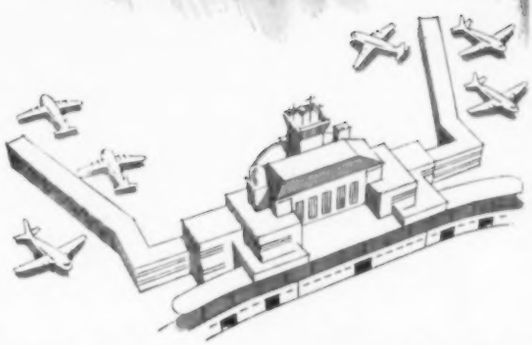
## PENNSYLVANIA *Silicone-Insulated* TRANSFORMERS

***at Greater Ft. Worth International Airport***

are 1000-kva ventilated units, three phase, 60 cycles, 150 C. rise, 12470Y — 480Δ volts. Silicone-Insulated Transformers (formerly known as "Class H", now NEMA Group 3) were pioneered by Pennsylvania. The following types and sizes now are available:

| TYPE | KVA | VOLTAGE |
|---|---|---|
| Ventilated | Up to 3000 | Up to 15 kv |
| Sealed-in Nitrogen | Up to 2000 | Up to 15 kv |





Power from two of the world's safest transformers — Pennsylvania *Silicone-Insulated* 150 C. Rise Transformers — would continue to light your way even after you stepped from the plane and entered the terminal building at Greater Ft. Worth International Airport. These two 1000-kva dry-type units are ideally suited for indoor installation because there is *no fire or explosion hazard* as with oil-filled transformers . . . *no risk from toxic fumes as* with Askarel units.

Also important, from the standpoint of public safety, is silicone insulation's *outstanding resistance to moisture* and other potential contaminants — one of the principal reasons for the trouble-free operating records of scores of Pennsylvania Silicone-Insulated units in service throughout the country. Such dependability — plus an *exceptional overload capacity* that can be called on in case of emergency — is of vital importance for the field and terminal lighting system at busy Ft. Worth International Airport.

**PENNSYLVANIA TRANSFORMER DIVISION**

McGraw-Edison Company • CANONSBURG, PA. • *Greater Pittsburgh District*

# NOW
# U.S. SAVINGS BONDS
# PAY YOU HIGHER INTEREST
# FASTER!

If you've always bought U.S. Savings Bonds for their rock-ribbed safety, their guaranteed return, the way they make saving easier—you've got one more reason now!

*Every Series E United States Savings Bond you've bought since February 1, 1957 pays you a new, higher interest—3¼% when held to maturity!* It reaches maturity *faster*—in only 8 years and 11 months. And redemption values are higher, too, especially in the earlier years.

About your older Bonds? Easy. Just hold onto them. As you know, the rate of interest a Savings Bond pays increases with each year you own it, until maturity. Therefore, the best idea is to *buy the new—and hold the old!*

The main thing about E Bonds, of course, is their complete safety. Principal and interest are fully guaranteed. They are loss-proof, fire-proof, theft-proof—because the Treasury will replace them without charge in case of mishap. Your Savings Bonds are as solid as a rock—backed by the full faith and credit of the United States.

Maybe you already know about Savings Bonds—as one of the 40 million Americans who own them today, or as one of the other millions who have used Bond savings to help pay for new homes, cars, or college educations, or to make retirement financially easier. If so, this is familiar territory to you—you *know* there's no better way to save.

But if you're new to the game, find out about Savings Bonds and what they can do for your future. Ask your banker, or check with your employer about the automatic Payroll Savings Plan that makes saving painless and easy.

PART OF EVERY AMERICAN'S SAVINGS

BELONGS IN U. S. SAVINGS BONDS

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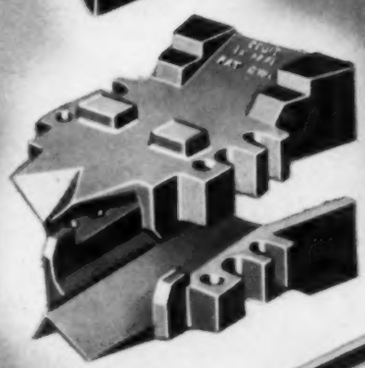
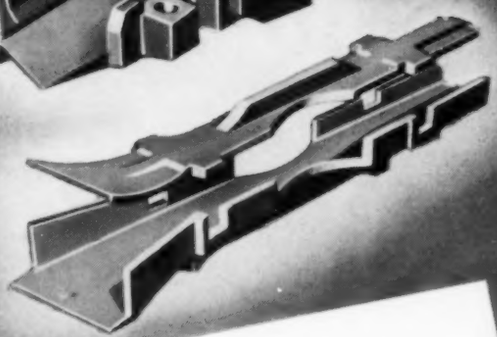
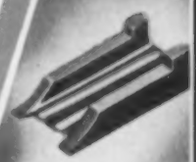
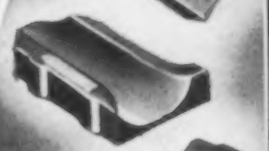
# TRANTINYL

## GUIDES THE STEEL INDUSTRY









"TRANTINYL" offers a quarter-century of metallurgical experience. "TRANTINYL" patented alloys were developed to function in specific operations where guides are required to resist wear and abrasion. Users of "TRANTINYL" alloys are astounded at the tonnage rolled over one set of guides.

Join the many satisfied users of "TRANTINYL."

**ROLLING MILLS:**
bar, hoop, strip, shape mill guides; and rollers.

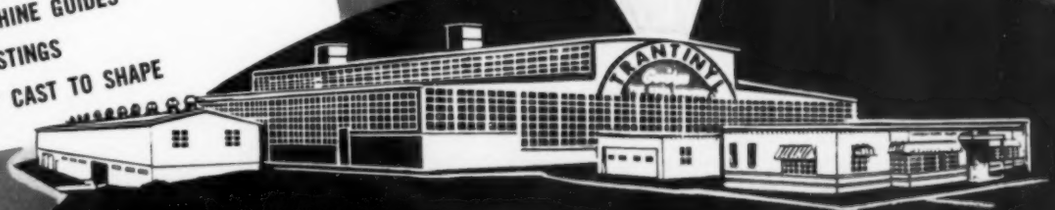
**SEAMLESS TUBE MILLS:**
guide shoes, rolling mill plugs and rolls, piercer points, etc.

**ELECTRIC WELD TUBE MILL:**
forming rolls, planishing rolls, tool holders, etc.

**STRAIGHTENING MACHINE GUIDES**

**HEAT RESISTING CASTINGS**

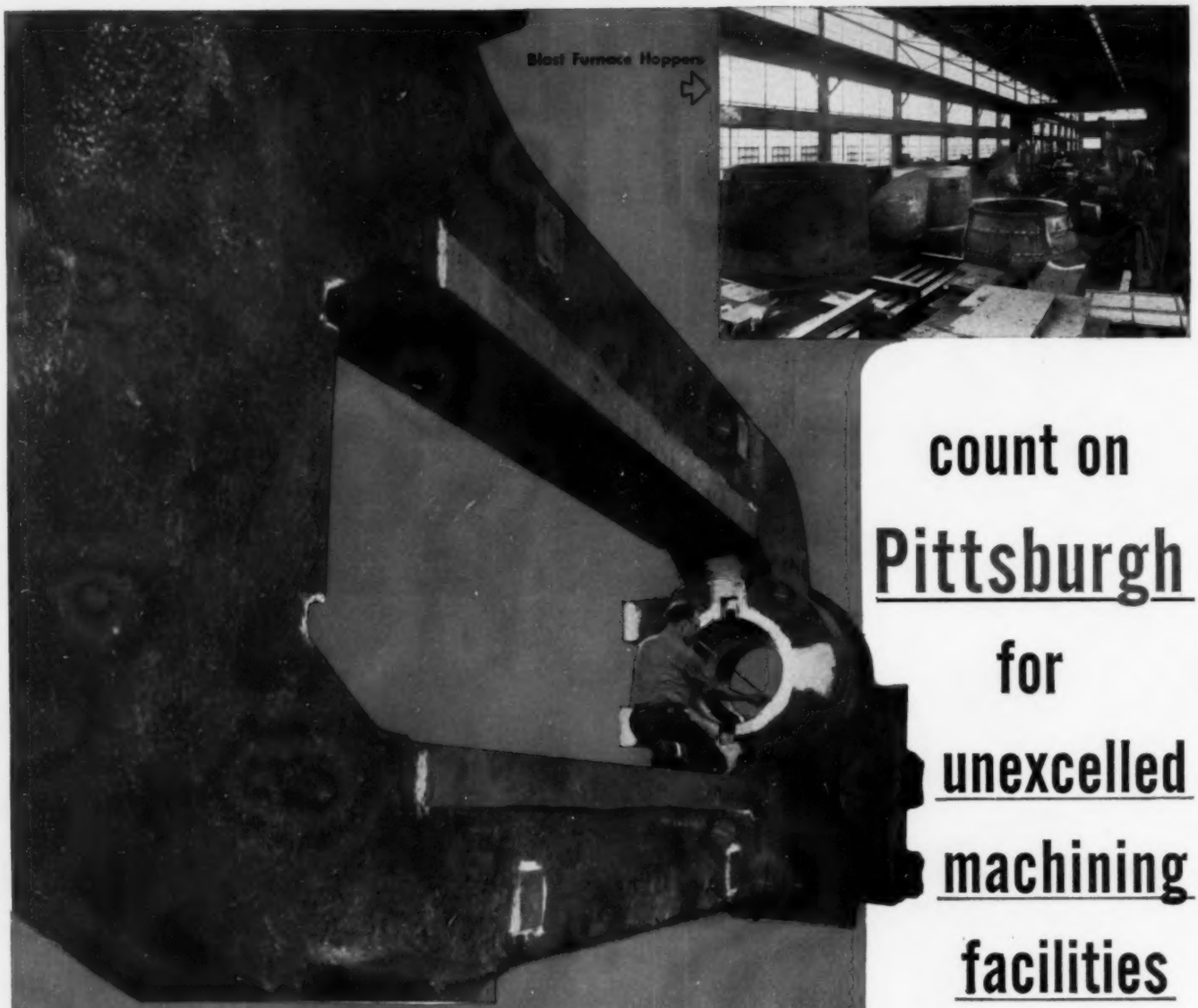
**"TRANTINYL No. 1" CAST TO SHAPE**




**Youngstown Alloy Casting Corporation**

**Youngstown, Ohio**

G-10



Blast Furnace Hoppers

# count on Pittsburgh for unexcelled machining facilities

4 High Mill Housing

Blast Furnace Bell on 20'0" Vertical Boring Mill

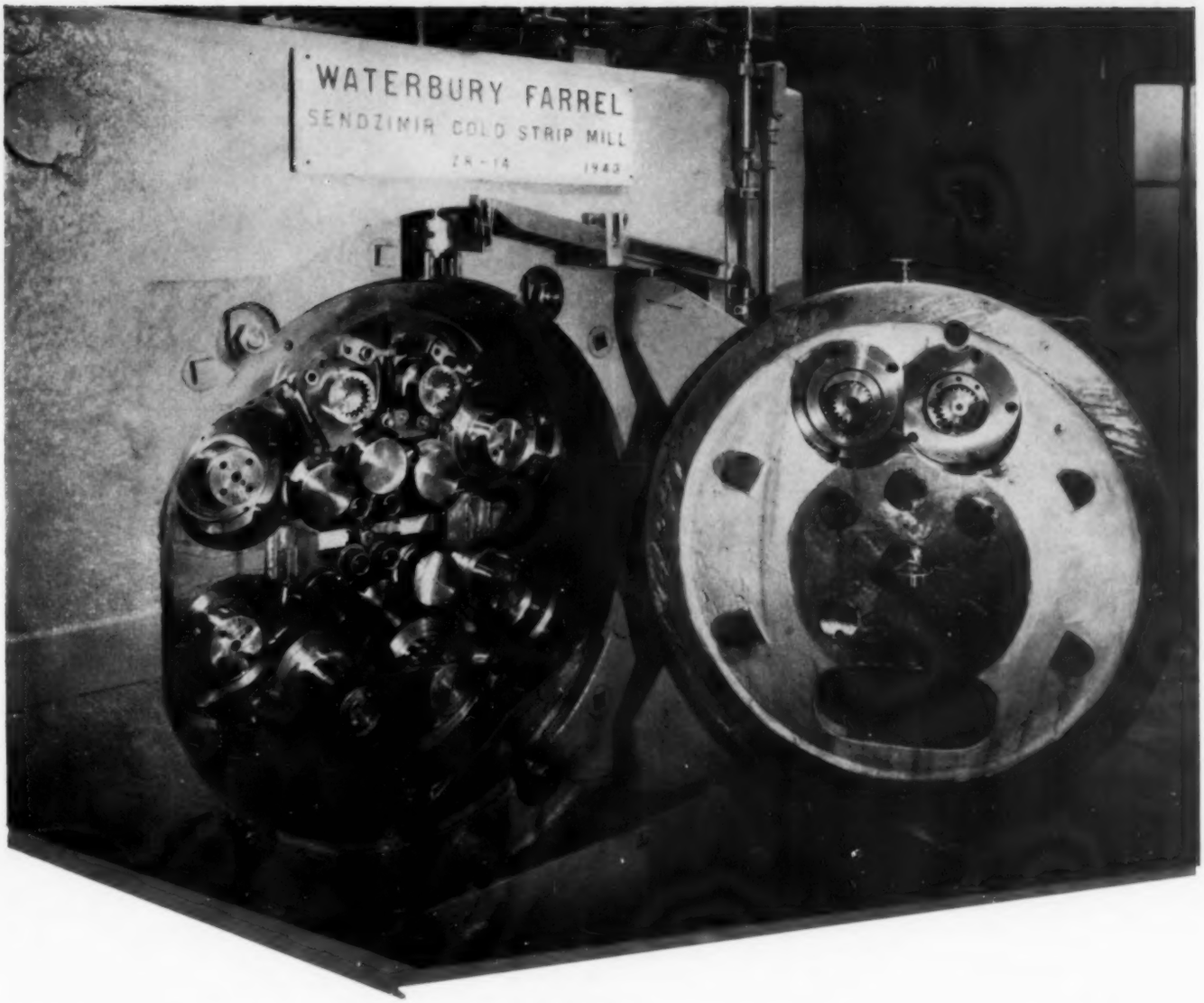
If it's a machining job that's big and tough to handle – you can count on Pittsburgh to do it. Giant castings such as those illustrated (produced by Pittsburgh Steel Foundry) are finished with remarkable precision.

Highly skilled personnel plus our wide range of equipment will pay off for you on king size machining problems.

"Electric and Open Hearth Steel Castings from 1 lb. to 100 tons"

**Pittsburgh**
ENGINEERING
& MACHINE CO.
*Division of Pittsburgh Steel Foundry Corporation*

P. O. BOX 986, PITTSBURGH 30, PENNSYLVANIA
PLANT AT GLASSPORT, PENNSYLVANIA




# Why Bearings, Inc. engineers were asked to solve this bearing problem

**FACT** — This cold strip mill performs a 70% reduction on light gauge silicon steel. The bearings needed for this job must carry heavy loads. Yet, they must be precise to help insure continuous production of strip without gauge variation from end to end of the coil.

**FACT** — The plant in which this mill was installed called a Bearings, Inc. engineer who, after a thorough study of the equipment and its uses, recommended the correct replacement bearing for the application. The user knew, from past experience, that Bearings, Inc. engineers had full knowledge of all types of bearings and could recommend the best from the many lines Bearings, Inc. distributes.

**FACT** — When the O.D. of these bearings become indented by fragments or roll flattened from extended service, we have them ground in shaft sets to within .0002″ section height . . . a further service of Bearings, Inc. and the manufacturer of the bearings.

This is the bearing service and follow through you can expect from Bearings, Inc., your authorized distributor for all nationally known makes of bearings. This is why we are called by our customers for any bearing problem. We'd appreciate the opportunity of helping *you!* Call or write NOW!

*Providing bearing service in the territories adjacent to our branches, listed below.*

## BEARINGS, INC.

**OHIO:** Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Mansfield • Toledo • Youngstown • Zanesville
**INDIANA:** Ft. Wayne • Indianapolis • Muncie • Terre Haute
**PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York
**WEST VIRGINIA:** Charleston • Huntington • Wheeling
**NEW JERSEY:** Camden • **MARYLAND:** Baltimore
**DELAWARE:** Wilmington •
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# TRABON

WITH ORIGINAL "METERFLO"

*Announces...*

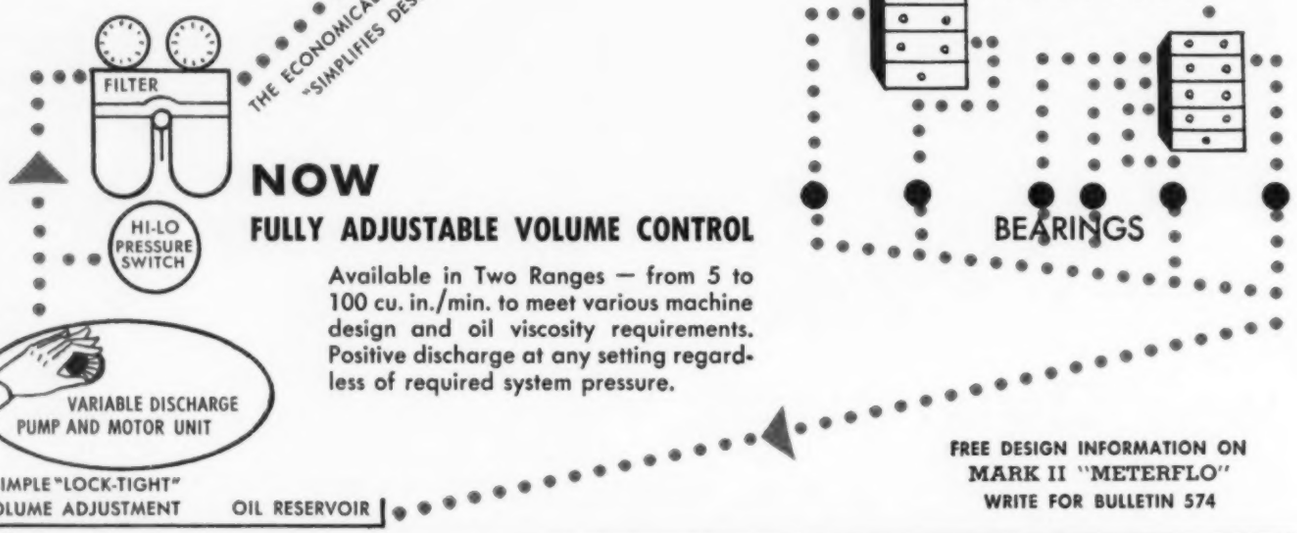
# MARK II "METERFLO"

## CIRCULATING OIL LUBRICATION SYSTEM

**POSITIVE OIL FLOW TO EVERY BEARING UNDER PRESSURE**

THE ECONOMICAL "SINGLE-LINE" SYSTEM "SIMPLIFIES DESIGN"

POSITIVE PISTON DISPLACEMENT METERING VALVES




**NOW**

**FULLY ADJUSTABLE VOLUME CONTROL**

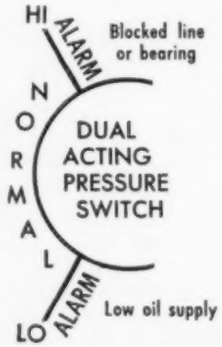
Available in Two Ranges — from 5 to 100 cu. in./min. to meet various machine design and oil viscosity requirements. Positive discharge at any setting regardless of required system pressure.

**FREE DESIGN INFORMATION ON MARK II "METERFLO" WRITE FOR BULLETIN 574**

## PLUS CALIBRATED DUAL PRESSURE SWITCH EQUIPMENT

Compact dual-acting pressure switch now includes calibrated adjustment for simple and ready adaptation to meet all field conditions. "Pressure-dampened" switch and gauge equipment—for longest equipment life and elimination of any momentary "false" pressure signals.

Wide normal operating range assures positive metered quantity **regardless of length of line or varying bearing resistances.**




**TRABON ENGINEERING CORPORATION**
**28785 AURORA ROAD SOLON, OHIO**

## NOTE TO MACHINE DESIGNERS

- Hi-Pressure dual cartridge filter — a turn of the handle permits cartridge change without stopping system—"quad" ring seal construction for leak-proof operation.
- Wide range metering valve sizes for ultra-fine metering requirements (i.e. exposed sliding surfaces)—plus accurate control over output ratios of 20-1 and higher within the same system.
- Protection against failure of oil to reach bearings for **any** reason.
- Constant positive pressure feed regardless of change in temperature or oil viscosity.
- "Packaged" power units—complete sump, pump, and control units available in any desired combination.

**For further economy, non-adjustable units also available.**

# Equipment News...

## LIFTING MAGNETS

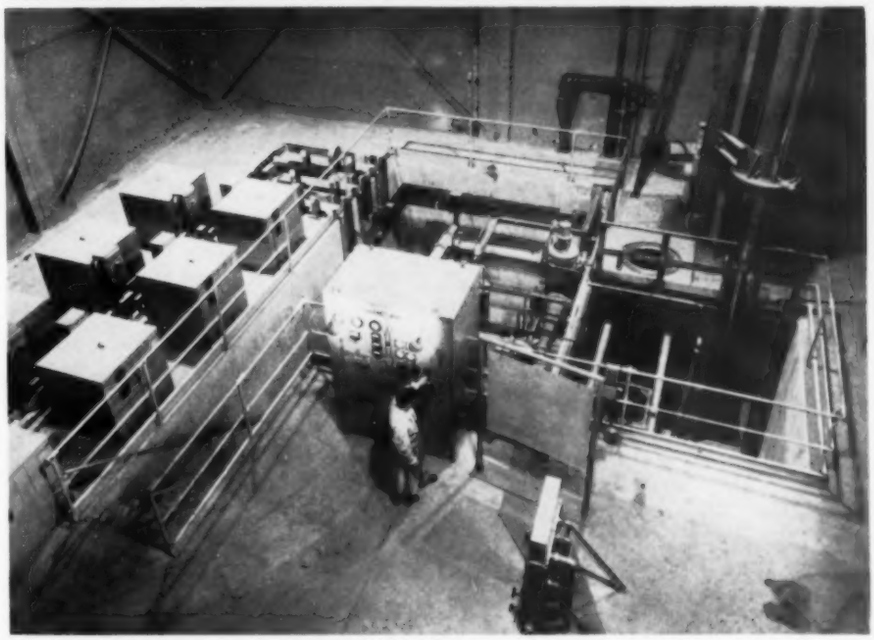
▲ The EC&M Division of Square D Co. has announced two large diameter bolted lifting magnets which are designed to permit field replacement of worn pole shoes and similar "do-it-yourself" tasks associated with normal magnet repair.

These magnets, known as Type SB, are 57 in. and 66 in. in diameter. Coils are wound with strap aluminum conductor on a mica and ecamica-insulated spool. Radial clamps hold the coil windings against movement on the spool. The completely wound spool is held in the magnet-case by continuous beaded welds to provide a watertight seal. Welds may be ground or chipped off by air-hammer for ready field removal of the spool and coil. Coil leads are on opposite sides of the magnet and terminate in separate chambers 180 degrees apart, through which the magnet, after being freed from internal moisture, is completely filled with self-polymerizing, insulating compound.

Tapered-head, through bolts hold the pole shoes in place and due to the tapered construction allow maximum life of pole shoes. Chains of cast manganese steel, are of 3-leg design with each separate leg terminating in a forged crane link for easy hook-on.

These bolted lifting magnets provide many improvements over previous design bolted magnets. They are mechanically stronger, have improved coil construction, and have high lifting capacity due to a better magnetic path which approaches the highly efficient magnetic circuit of all-welded magnets.

## NEW VACUUM ARC FURNACE NOW IN OPERATION



**This new 16-in. capacity vacuum arc melting furnace is now in use for production melting of molybdenum and molybdenum alloys at the Universal Cyclops Steel Corp., Bridgeville, Pa. Designed and built by the General Electric Co.'s Industrial Heating Department, the furnace casts an extremely pure ingot, since it removes gaseous impurities, reduces segregation, and produces a superior grain structure. The furnace can also be used for iron or nickel base alloys, titanium and zirconium. At left are ten selenium rectifiers, producing a power supply of 15,400 amperes. At the operator's station (center) are the "flow" type control panel, the viewing screen on which an image of the arc is projected and the visual flowmeters for cooling water. The vertical cylinder (right, rear) is the electrode housing in melting position. Not visible directly below it is the water-cooled crucible into which the electrode is lowered as it melts. Protruding from the pit, to the right of the furnace, is an electrode ready for the next melt. To load, the electrode housing is swung over the electrode, and the electrode is drawn up into the housing, then swung back over the crucible.**

## WIRE FLATTENING MILL

▲ Developed by Stanat Manufacturing Co. is a new tandem wire flattening mill designed for high speed operation while holding extremely close tolerances. The machine consists of two mill stands, each equipped with 8-in. diameter x 5-in. width rolls, faced with cemented tungsten carbide rings. A welded structural steel base carries the mill stands, two dancer roll mechanisms and a traversing recoiler. The mill is capable of producing strip in thicknesses ranging from 0.010 in. up and in widths to $\frac{5}{8}$ in.

Designed to offer maximum flexibility of operation and arrangement and requiring no elaborate foundation, the mill is available either as a completely self-contained package unit or as individual components for erection at the customer's plant. As a self-contained package unit, the base serves as a partial enclosure for wiring and piping, providing maximum safety to operating personnel.

The roll housings of both mill stands are constructed of high tensile semi-steel castings, each roll housing having a cross-sectional area of 60 sq in. The extra strength of the roll housings permits the mill to take loads far in excess of usual requirements with minimum deflection. Vertical loads are taken by heavy duty cage type needle roller bearings and horizontal thrust loads are taken by ball bearings.

To insure accurate pass control, each mill stand is equipped with a single handwheel worm gear screwdown with micrometer dial graduated in 0.0001 in. The screw-down mechanism employed, offers the most exacting adjustment of the roll setting even when the mill is in op-

eration. The screwdown is equipped with hardened alloy steel screws, having 8 pitch ground Acme threads and a worm gear ratio of 20:1. A single revolution of the handwheel corresponds to 0.006 in. of vertical screw-down movement. A simple clutch device is fitted onto the horizontal screwdown shaft to provide rapid correction of roll parallelism.

For longer service life between regrinds, tungsten carbide sleeves are fitted to the mill rolls which also make possible longer roll life at high speeds while aiding substantially in providing better surface finish and closer size tolerances. Close width tolerances are maintained by means of quick release vertical edging unit mounted on the entry side of the second mill stand. The edging rolls are of highest grade alloy tool steel, furnished with a number of grooves to suit the various types of edges and stock sizes to be produced.

The entire drive system operates on the basis of the highly refined Ward-Leonard type variable voltage principle, wherein the two mill motors receive their power from a single generator. A manually operated potentiometer accelerates and decelerates all motors together as a unit. The No. 1 mill stand is driven by a 20-hp heavy-duty motor and the No. 2 mill stand is powered by a 15-hp heavy-duty motor, while the recoiler is driven by a 10-hp motor and is equipped with an electromagnetic 50 ft lb disc brake for instantaneous stopping. Horsepower of these motors can be altered to suit individual requirements.

When processing relatively light wire gages, synchronization between the roll stands and recoiler is obtained by the dancer roll mechanisms. When flattening heavier sizes of wire the dancer roll stands are by-passed and the vernier rheostats are set manually. The motors are slightly compounded to aid synchronization.

The recoiler is a heavy-duty traversing spool type, wherein wire feeds in a straight line and is laid uniformly on the spool without end buildup or bunching. The recoiler is synchronized electrically to provide constant tension and is designed for winding coils of various sizes having a maximum weight of 500 lb. The pitch of wire lay is infinitely variable within machine limitations. A handwheel control permits adjustment of the traverse width from a minimum of 1½ in. to a maximum of 12 in. This feature is of great value to job shops where many spool sizes are encountered. The versatility of this unit is further enhanced by the use of a flange mounted and bolted recoiler shaft. By changing shafts, the recoiler may be used for very small reels as well as larger ones.

The new unit is offered with a circulating system for the roll neck bearings, a strip coolant system, continuous gaging equipment to measure both thickness and width of the material, a die holder and oiler mounted on the entry side of the No. 1 mill stand and a cone type pay-off stand equipped with a snarl switch.

## PUSH-BUTTON STATIONS

▲ Cam-operated push-button stations designed for heavy-duty applications and rated 600 volts, a-c or d-c are available from The Euclid Electric & Mfg. Co. These


From first heat to heat treat . . .

LOFTUS

designs and builds them better

International Harvester Company, West Pullman Works

COVER TYPE
ANNEALING FURNACES

DIRECT-FIRED SINGLE-STACK
Generally Recommended
for
Greater Productivity per Investment Dollar
and
Flexibility with Economy

LOFTUS
*Engineering Corporation*
1 Gateway Center, Pittsburgh, Pa.
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57.12.4

# How perfectly simple —this Fast's Coupling with purely mechanical flexibility!

1. A hub is keyed on each shaft. Hubs are splined at maximum distance from shaft ends.
2. Floating sleeves surround hubs. Sleeves are splined to engage hub splines.
3. Sleeves compensate for shaft misalignment by assuming neutral position between two hubs.
4. Because of distance from shaft end, any misalignment between splines is mere fraction of same misalignment between shafts.
5. Sleeves carried on bearing rings, located on transverse center line of hub spline faces (the load-carrying surfaces) no crank action, no vibration.
6. Lubricant is centrifugally forced into spaces between engaged splines, forming a film.

For 35 years the most positive, dependable means of coupling machines to their power source . . . Fast's Couplings have no parts subject to repeated bending, tension or compression. Because there is no metal-to-metal contact, *there is no wear*—in fact, many Fast's Couplings in use for over 30 years show no signs of wear when disassembled! No leather, plastic or rubber oil seals. Lubricant film distributes pressure over a considerable area, diminishing localized stress at pressure points on the load-carrying teeth. Perfectly simple? Yes . . . and foolproof!

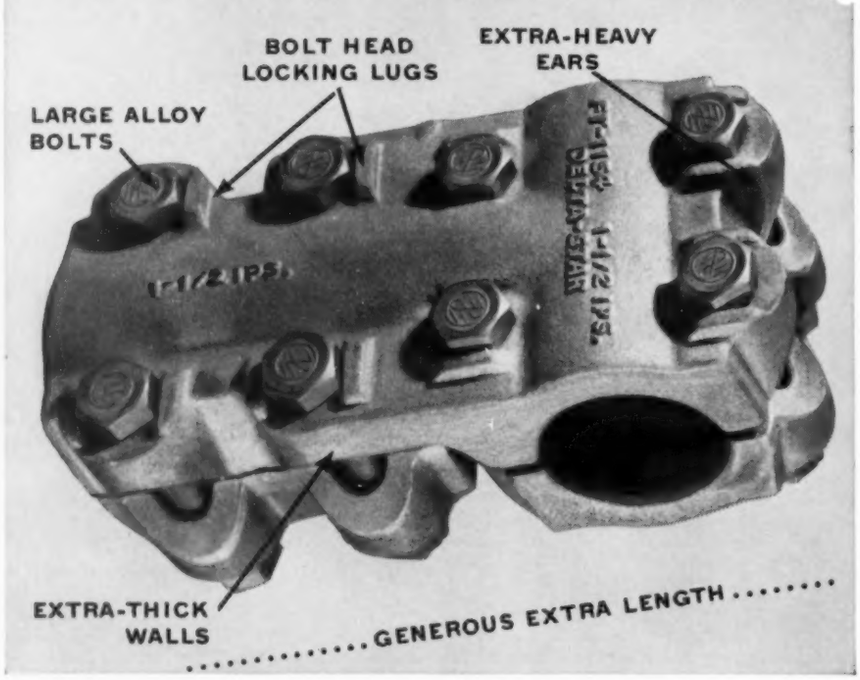
**For coupling catalog,** technical advice or assistance from Koppers field engineers, write: KOPPERS COMPANY, INC., *Fast's Coupling Dept.,* 3008 Scott Street, Baltimore 3, Maryland.

THE ORIGINAL **FAST'S Couplings**

KOPPERS

**METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD.**
This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans.
*Engineered* Products Sold with *Service*.

# New.. Delta-Star Heavy Duty Aluminum Connectors!




**Delta-Star announces a complete new line of connectors. Extra rugged construction and engineered for maximum service life under all conditions...**

Particularly important in this new line are the heavy walls and generous overall dimensions. With these features pressure is distributed to permit optimum contact yet with negligible cold flow...All sizes and ranges of conductors are cast on surface of each connector...Can be supplied in types and sizes to meet all connector requirements. For further information, write Delta-Star Electric Division, H. K. Porter Company, Inc. — 2437 West Fulton Street, Chicago 12, Ill.

District Offices in Principal Cities

**DELTA-STAR ELECTRIC DIVISION**

**H. K. PORTER COMPANY, INC.**

Divisions of H. K. Porter Company, Inc.: Connors Steel, Delta-Star Electric, Henry Disston, Leschen Wire Rope, Quaker Rubber, Refractories, Riverside-Alloy Metal, Vulcan Crucible Steel, W-S Fittings and H. K. Porter Company (Canada) Ltd.


stations provide for practically an unlimited number of different sequences of operation, and are available from one to five speed-points in each direction for a total of eight circuits.

Sturdily constructed to withstand hard usage and abuse, their small cross-section permits comfortable, non-fatiguing, one-hand operation. Steel shrouds guard the large operating buttons. The heavy, all-welded steel frame (that includes the end-caps and front) has a heavy, fiber-glass, easily-removed rear cover that affords quick inspection of the silver-to-silver contacts without disturbing any wiring. The threaded conduit fitting is an integral part of the top end-cap which also has welded to it a double-suspension cable hanger.

Extra features include heavy-duty, control-circuit toggle disconnects, pilot lights, selector switches, and maintained-type contacts.

## REFRACTORY GUN

▲ A new batch type refractory gun has been manufactured by Ridley and Co., Inc. Nozzle controls permit the one-man operation of material, air and water flow.

The guns come in four sizes to fit the needs of all cupola and electric furnace operations and their available material capacities are 1700, 3000, 4300 and 5600 lb. The guns handle most granular cement-like materials from 30- to 160-lb bulk density.

## DUST COLLECTOR

▲ A centrifugal dust collector said to have the highest efficiency and lowest erosion rate of any mechanical dust collector on the market has been announced by Hagan Chemicals and Controls, Inc.

The collector has had marked success in the elimination of fly ash from coal-fired steam boilers in steel mill power plants. Collection efficiencies range as high as 97 per cent in some installations.

Most centrifugal collectors, consist of an inlet chamber connected directly to a battery of vertically-mounted annular separating tubes, a dust-collecting hopper, and clean gas discharge chamber. The collector admits dust-laden gases into the inlet nozzles of the separating

tubes, imparts a centrifugal motion to the gases, then changes the direction of flow.

Entrapped dust particles are forced to the perimeter of the outside shell where they spill into the discharge hopper. The hot cleaned gases recover from the induced centrifugal motion and resume their natural course upward through the inner annulus and out the clean gas chamber.

Hagan officials attributed the unusually high efficiency of this collector to the unique design of the venturi-spiral vaned nozzles at the inlet of each separating tube. This design effects an almost instantaneous six to one increase in gas velocity, greatly intensifying the tangential or outward thrust characteristics of the centrifugal action. Even the most minute particles, five microns and under, are ejected and collected.

## GIANT LIFT TRUCK

▲ Completion of a high lift diesel electric lift truck, capable of handling loads up to 200,000 lb., has been announced by the Yale and Towne Manufacturing Co.

The truck is designed to handle huge dies, expediting their transit between outside storage and inside presses. The new truck, betters by 40,000 lb in capacity any lift truck formerly produced by Yale.

Its total weight is 77,000 lb and the truck is 21 ft 4 in. long. Its die carrying platform measures 13 ft by 8 ft. The truck is designed to provide 2 ft 4 in. of lift hydraulically.

The truck is driven by four 36-in. diameter x 16-in. face drive wheels and steers completely hydraulically through eight sets of castors wheels.

Despite its weight and bulk, hydraulic power steering permits the lift truck to be guided with less steering effort than that encountered in an automobile equipped with power steering.

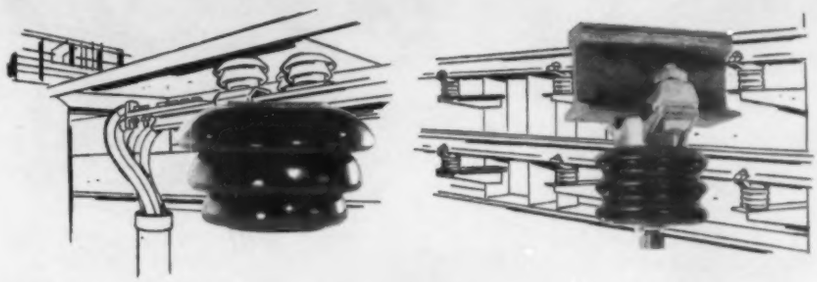
## BURNERS

▲ A complete line of field-tested gas, oil, and dual-fuel burners for use with preheated air at temperatures up to 1200 F has been announced by The North American Mfg. Co. High temperature alloys and refractory are used for the in-


# STRENGTH

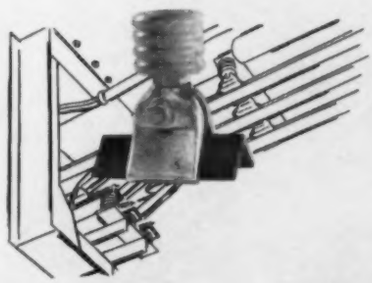
## Which kind of strength do you need in insulators for traveling-contact equipment?

**MAXIMUM ELECTRICAL STRENGTH**



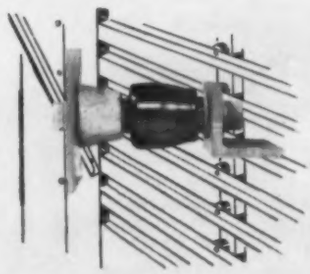
Wet-process porcelain insulators, such as these, offer outstanding electrical properties for high-voltage contact-rail insulation. Especially recommended where dirt, moisture, and other contaminants prevail.
Also available are dry-process porcelain units for power circuits.

**MAXIMUM IMPACT STRENGTH**



Molded polyester-fiberglass insulators and fabric-reinforced insulators of this general type have exceptional impact strength and vibration-resistance combined with good electrical properties. Tailored to resist chemicals, thermal shock, weathering.

**MAXIMUM TENSILE STRENGTH**



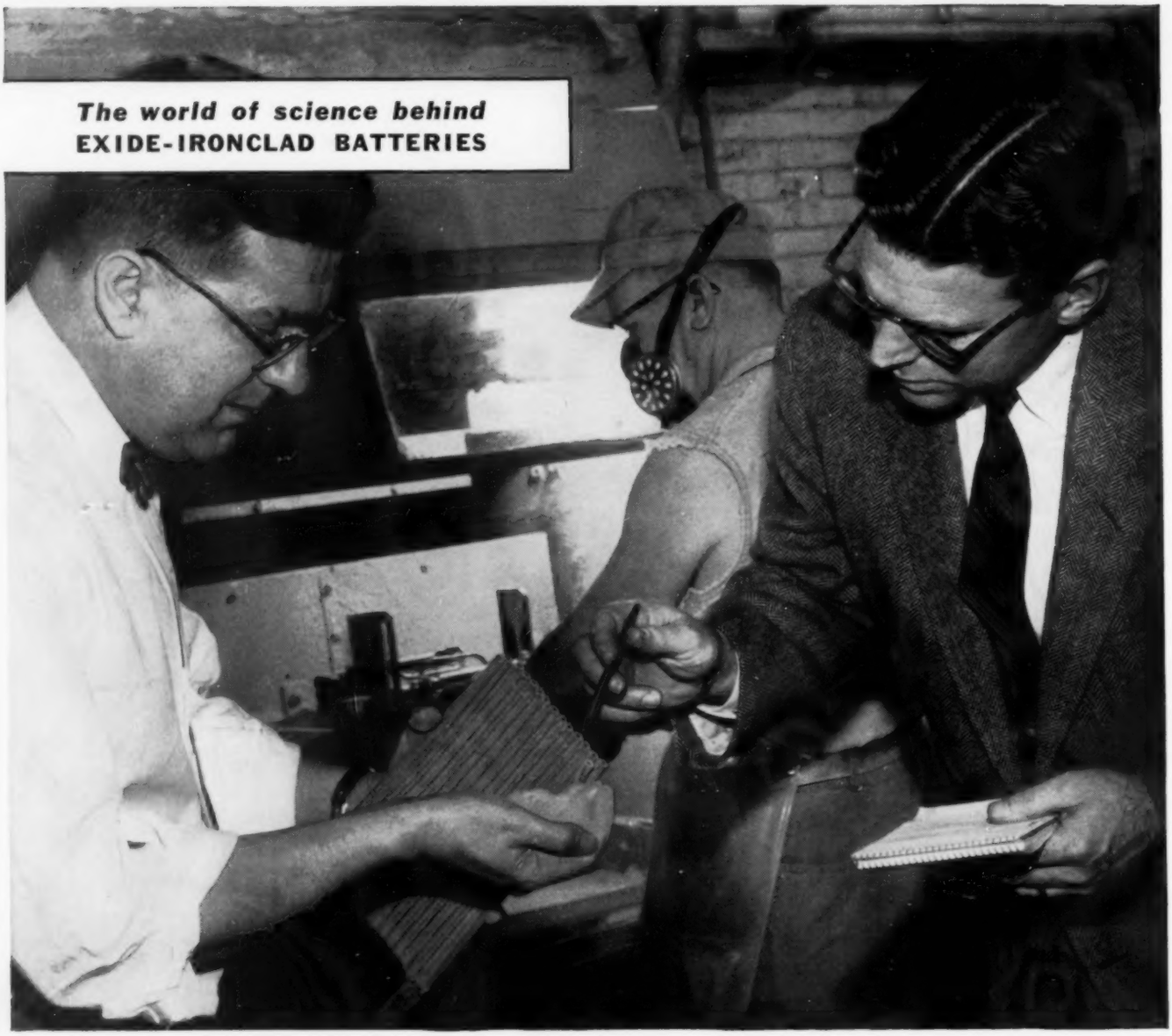
Molded Giant Strain insulators, adaptable to miniaturization where space is restricted, offer unusual mechanical strength. A very economical insulator having diverse applications.

## TO HELP YOU DECIDE

. . . on the right combination of properties to meet your insulator needs, Delta-Star engineers from coast to coast invite your problems. Phone the nearest Delta-Star district office or write to Electric Service Works, Delta-Star Electric Division, H. K. Porter Company, Inc., 17th & Cambria Sts., Philadelphia 32, Pa.

**ELECTRIC SERVICE WORKS**
**DELTA-STAR ELECTRIC DIVISION**
**H. K. PORTER COMPANY, INC.**

***The world of science behind***
**EXIDE-IRONCLAD BATTERIES**



*Being interviewed is E. A. Wagner, Product Engineer*

## *"This oxide blend packs more power per ounce"*

*At the Exide Laboratories*—**Reporter:** More power, Mr. Wagner? Do you mean the blend of oxides in Exide-Ironclad is different from that used in other batteries?

**Wagner:** Absolutely. We can use the more active oxides that give the batteries higher capacity.

**Reporter:** Why do you say *can?* Can't other batteries use these oxides too?

**Wagner:** It isn't likely. First, this blend is the result of more than 40 years of Exide research—and it's an Exide exclusive. Second, we can use it successfully because of the unique tubular construction of the Exide-Ironclad positive plate.

**Reporter:** How does tubular construction help make it a better battery?

**Wagner:** Because the cylindrical power tubes hold the tiny oxide particles firmly in electrical contact clear through the charge and discharge cycle. So Exide-Ironclad Batteries can maintain their high capacity—even under severe vibration—for years of service.

**Reporter:** Obviously, this is an important feature of Exide-Ironclad Batteries.

**Wagner:** Yes it is, but it's just one of many engineering details that contribute to its high capacity and long life.

**Note to battery users.** Whenever you order heavy duty batteries or the equipment that requires them, be sure to specify Exide-Ironclad. For bulletin, write Exide Industrial Division, The Electric Storage Battery Co., Phila. 2, Pa.

THE ELECTRIC STORAGE BATTERY COMPANY **Exide®**

ternal parts and the body of the burner is refractory lined.

When burning gas these Series 6819 burners produce long radiant flames that are very stable. An alternate form of the burner for short clear flames is also available. Heavy oil is atomized by the use of steam or compressed air. The burners can be supplied with either internal or external mixing type atomizers and both are retractable for protection during gas firing. Latch screws permit quick and easy removal of the entire atomizing assembly. All burner parts can be removed from the back without disconnecting the burner from the furnace or hot air pipe.

## FLOW METER

▲Using preformed highly sensitive diaphragms, stacked to nest together for positive overrange protection to full static pressure, the new Type 37 diaphragm meter manufactured by The Foxboro Co. for accurate flow measurement presents a new concept in mercuryless meter design.

Each pair of diaphragms forming the low pressure (range) and high pressure (compensating) diaphragm elements is welded at the outer circumference and to opposing faces of a series of spacing rings at the inner circumference. Overrange pressure on either element forces filling fluid through a connecting passage, around an adjustable damping plug and into the opposite element. The unit under pressure compresses so that the spacing rings form a metal-to-metal column and each pair of diaphragms is nested, preventing overrange damage.

Measurement is unaffected by temperature variation of the liquid in the elements. A bimetallic compensator inside the high pressure element varies the fluid capacity of the element according to temperature changes.

The low pressure element, working against a thermally stable range spring, is connected to a bellows-sealed drive arm which operates through a metal flexure to drive the indicating or recording mechanism.

Differential ranges are 0–20, 0–50, 0–100 and 0–200 in. of water. Meter is available in rectangular or circular case, yoke or flush mounted, for 2000 psi maximum pressure. Diaphragms are of Type 316 stain-


DURASPUN

20-FOOT FURNACE ROLLS
Centrifugally Cast

. . . of Duraloy HH Alloy, one of the most widely used high chrome, medium nickel alloys.

Two items concerning these furnace rolls may be of particular interest:

a—the size: 20 feet long—14" OD, ¾" wall thickness

b—welding operations by which reducing cones and shafts (both statically cast of the same alloy) were welded to the centrifugally cast rolls

These two items will serve to emphasize two phases of our service: (1) the large size centrifugally cast tubes we are able to produce and (2) our machining and finishing facilities, including welding.

Our new 16-page general Bulletin — 3354-G — gives complete details. Would you like a copy? When writing or calling would you mind telling us the general nature of your high alloy casting requirements? Better yet, if you have specific requirements on which we could help, let us have the details.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

less steel; body is of forged steel, cadmium plated or Type 316 stainless steel; range spring of Ni-Span C metal; and end caps of forged steel, cadmium plated or forged Type 316 stainless steel. Pressure connections are tapped for ¼ or ½ in. NPT, optional by turning the end caps.

## CONTROL CENTER

▲Announced by the Westinghouse Electric Corp. is a new Class 11-350 control center for groups of a-c motors. The new unit houses controls for 3-phase a-c systems at 220 volts (1–100 hp) and 600 volts (1–200 hp).

All controls are centralized in one group of stationary, interchangeable enclosures, each with a grouping of modular starter units. Individual structures are 90⅜ in. high and 20 in. wide, and may be combined in straight-line, L-shape or U-shape assemblies. They are available for both front mounting and back-to-back mounting of controls, in NEMA 1 indoor or NEMA 3 outdoor weather-resistant enclosures.

Each structure contains a main horizontal 3-phase bus lowered 12 in. from the top, and a 3-phase vertical bus for distribution of power to starter units.

Modular starter units have uniform width and depth, while heights vary from 9⅓ in. to 70 in. in multiples of the two basic sizes, 14 in. and 9⅓ in. All sizes are removable and may be intermixed in the same structure. Starters are of the combination-magnetic type consisting of a circuit protective device and a starter. The circuit protective device may be a Type AB air circuit breaker or a fusible disconnect switch used in combination with a motor starter. Plug-in stabs are provided on the rear of each draw-out starter unit for power connection to the vertical bus. Control unit doors have rolled edges and a neoprene gasket.

Starter units are available in NEMA Type A with no terminal, NEMA Type B with individual terminal blocks on each starter, or NEMA Type C with individual unit terminal blocks and complete factory wiring to master terminal blocks at either the top or the bottom of each structure.

## SHAFT MOUNTED DRIVE

▲A new higher ratio of 24:1 (or 20:1 in 2 smaller sizes) has been added to the line of all-steel, double reduction, shaft mounted drives, manufactured by The Falk Corp.

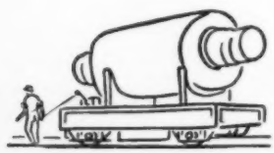
The outside dimensions and torque rating remain the same. Practical advantages attributed to the higher ratio units include (1) the use of smaller sheaves to obtain a given output speed, and (2) a saving in motor cost when, because of the lower output speed, a 1750-rpm motor can be used instead of a more expensive slower speed motor.

Units available for horizontal and vertical application, in ½- to 30-hp ranges.

## INERT GAS GENERATOR

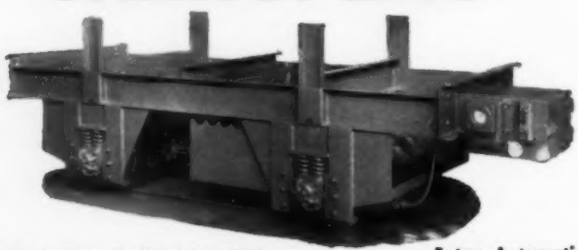
▲Thermal Research and Engineering Corp. announces increased acceptance for its inert gas generator developed and introduced earlier this year. Operating on entirely new principles, the generator is intended to meet the needs of many industries for inert gases used to blanket or purge hazardous locations of combustible atmospheres.


HANDLES THE BIG LOADS WITH BIG SAVINGS



100-ton Battery Operated

ATLAS *Safety Type* TRANSFERS



5-ton Automatic Controlled

**ATLAS SAFETY-TYPE TRANSFER CARS** can be provided in almost any capacity for storage battery, diesel or gas-electric, or cable reel service.

They are safe because there is only one control lever, and the car moves only when the operator holds the lever.

*Request "Walk-Along" Bulletin 1283.*

ATLAS CAR & MFG. CO.
1100 IVANHOE ROAD
CLEVELAND 10, OHIO

ENGINEERS AND MANUFACTURERS SINCE 1896

The inert gas generator, being offered in various sizes from 5000 to 150,000 standard cu ft of gas an hour, produces an inert atmosphere consisting of essentially carbon dioxide and nitrogen. The heart of the system is a patented combustion system which is characterized by high velocity short flame combustion with either gas or oil. The burners contain their own combustion chamber where 90 per cent of combustion takes place. Because of this, the burners have no flame impingement problems and are able to maintain stability under a wide range of conditions and against various back pressures.

The stability of the combustion system makes possible an inert gas generator in which the burner fires directly into a column of water. The water is used to cool the hot gases of combustion to the proper temperature. Conventional inert gas generators normally utilize a large combustion chamber and are unable to fire directly into a coolant because of flame impingement and stability problems. To reduce gas temperatures, conventional inert gas generators use a complicated heat exchanger system. While this approach yields satisfactory results, heat exchangers are expensive and are subject to corrosion and fouling.

The Thermal gas generator, because of its simplicity and ability to operate under a wide range of conditions, offers an economical answer to inert gas needs.

The combustion system was adapted from military techniques for industrial use. It burns gas or a wide range of fuel oil with identical flame characteristics and produces high velocity, high temperature products of combustion at extremely high burning rates.

## RELAY PILOT VALVE

▲A high-capacity relay pilot valve that converts any high grade commercial cylinder to a double-acting power position has been announced by Hagan Chemicals & Controls, Inc.

Designated the remote mounted positioner, the low cost unit converts input air signals to pneumatic or hydraulic signals up to 150 psig for actuating power pistons, diaphragm motors and rotary vanes. Standard input signal range is 0 to 30 psig.

The compact positioner is particularly adaptable for use with power pistons since it enables the user to choose the most desirable power cylinder from the standpoint of bore, stroke, and style of mounting.

A conventional application is the positioning of large butterfly valves in response to signals from a remote control point. The air signal acts on a diaphragm in the positioner, displacing the small servo valve and sending air or hydraulic pressure to either end of the power cylinder. This, in turn, actuates the butterfly valve.

The same motion is transmitted through follow-up linkage to the positioner cam, returning the servo valve to null position when the butterfly valve reaches the position corresponding to the air signal value.

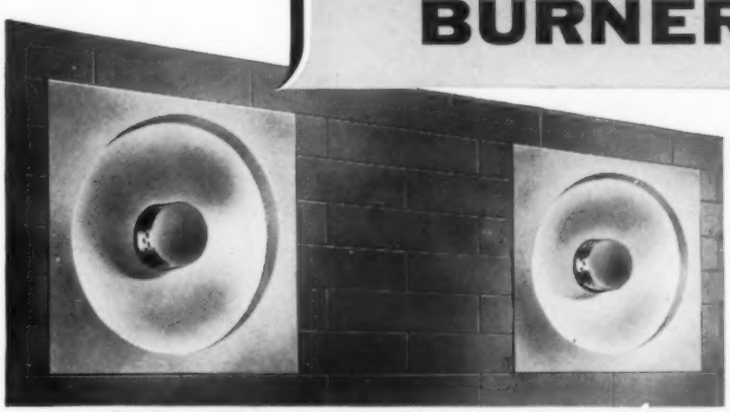
## HEAVY DUTY FANS

▲A rugged line of fans designed for heavy industry, commercial installations and public buildings, has been announced by the Chicago Blower Corp.

The direct drive units, constructed of either cast iron or steel


for intense concentration of heat...

The BLOOM HTR BURNER



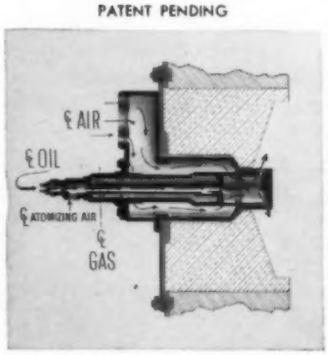
The Bloom HTR Burner provides identical operation on either gas or oil.

This burner enables the engineer to design a heat pattern with excellent results, because it has the unique characteristic of providing localized high heat release with low forward velocity. The burner can be located to fire directly at the material without flame impingement. Roof firing is easily accomplished and provides uniform hearth temperature.

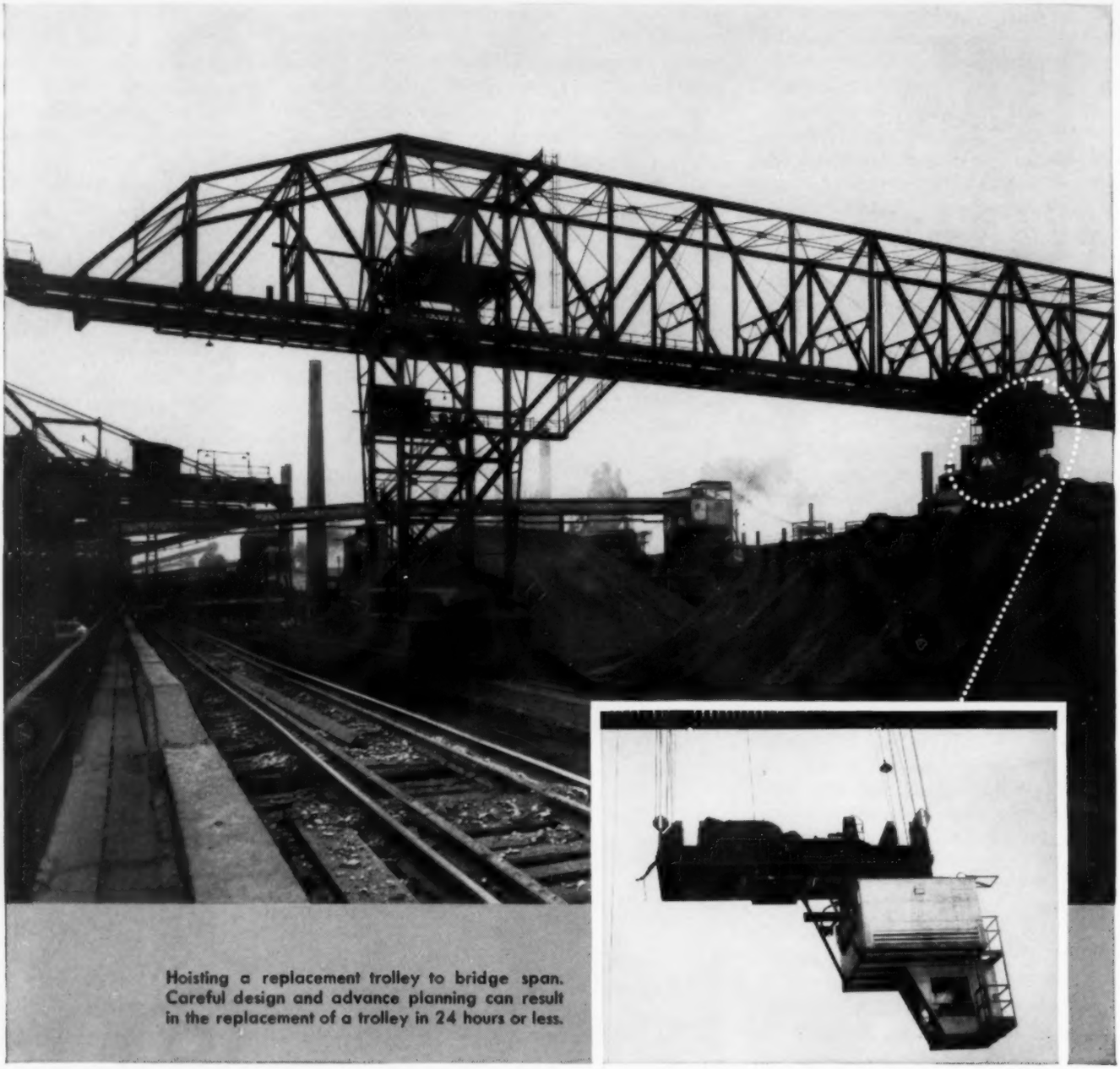
This burner has been very successful in its application to tube upset furnaces; continuous strip annealing, coating, and pre-heating lines; high speed billet heating furnaces; and batch-type forge furnaces.

The Bloom High Thermal Release Burner with its sturdy construction is ideal for applications requiring speed and precision heating.

PATENT PENDING




BLOOM ENGINEERING CO., INC.
837 W. North Avenue Pittsburgh 33, Pa.



Hoisting a replacement trolley to bridge span. Careful design and advance planning can result in the replacement of a trolley in 24 hours or less.

## Eastern steel mill modernizes 4 old bridges with DRAVO REPLACEMENT TROLLEYS

This eastern steel mill has found that old bridges can easily be restored to high productive capacity by replacing old and worn-out trolleys with new and modern Dravo replacement man trolleys.

The new trolleys permit faster operating speeds and will eliminate the excessive downtime for repair which had hindered bridge operations. The useful life of the bridges has been greatly extended, and production increased materially.

Replacement of inefficient, worn or inadequate trolleys can improve operations at a small fraction of new bridge cost. Consultation with a Dravo engineer may help you eliminate a production bottleneck. For more information, write or phone DRAVO CORPORATION, PITTSBURGH 25, PENNSYLVANIA.

**DRAVO**
CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

housings, depending upon specific applications, utilize a forward curved aluminum wheel and streamlined inlets to produce a low operating noise level at optimum output. Available in 9 different sizes, these fans are furnished for 90 deg adjustment as to position of discharge.

The cast iron, direct drive unit, type "LV" (large volume) is designed to produce capacities up to 2124 CFM, with pressures up to 1½ S.P. Its counterpart, the "PB" (pressure blower) is also constructed of cast iron to produce long wear with a minimum of maintenance. Designed for exhausting buffing and grinding dust or other similar materials, this unit produces ranges up to 335 CFM with pressures up to 4 in. S.P., again depending upon size of unit.

The steel housing, direct drive units, available in five sizes, are constructed of heavy sheet steel with continuous welded seams. Designed for operations such as air cooling, lavatory exhaust, zone ventilation and similar applications, these units produce ranges from 400 CFM up to 3250 CFM with pressures to 1½ S.P.

The steel housed packaged V-Belt Drive fan unit is also designed for high efficiency, long operational life, and requires a minimum of space. Manufactured in 14 different sizes, ranging from 7 5/16 in. to 33 in., these wheels produce a noiseless operation. These units are designed for volumes to 18,000 CFM and pressures to 1½ in. S.P. This basic design and operational procedure make these units suitable for installations in office buildings where efficiency and quiet operation are necessary.

## POTENTIOMETERS

A new line of small-size self-balancing electronic potentiometers and bridges has been announced by The Bristol Co.

The new instruments match the appearance of the company's pneumatic Metagraphic instruments for graphic panel and console use. They are made in both recording and indicating versions, and the two types of chassis are interchangeable through plug-in construction features. The recorder uses a 3-in. strip chart. Face dimensions are only 5 x 5⅛ in.

The instruments are available in three basic circuit types: a-c Bridge, d-c Potentiometer, and Differential transformer balance types.

## *Book Reviews*

**"The Casting of Steel,"** edited by W. C. Newell, has recently been published by the Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. The book contains 598 pages, 10 x 6 in., is cloth bound, and sells for $27.50. This is the work of a group of British authorities who have written upon various aspects of the subject. The general plan or structure has been first to deal with the essential basic principles, then to show their practical working, and to conclude with the consequences or the properties of the product. This same plan or "micro-structure" has been carried out in the individual chapters as far as applicable. The purpose of the book is to give those with only an academic training familiar ground to build an understanding of the practical problems of the steel casting industry; and to enable those engrossed in the practical aspects to be able to start in the middle of the book and refer back to the basic principles. The book contains numerous illustrations, tables and figures to supplement and explain the text.

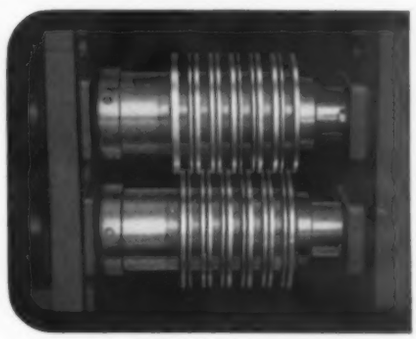
**"The Heating Ventilating and Air Conditioning Guide 1957,"** 35th edition, has recently been published by the American Society of Heating and Air Conditioning Engineers, 62 Worth St., New York 13, N. Y. This book contains 520 pages, 6 x 9 in., is cloth bound, and sells for $12.00. The book contains a technical data section of reference material on the design and specification of heating, ventilating, and air conditioning systems based on the Society's Transactions and the investigations of the research laboratory and co-operating institutions, and the practice of the members and friends of the Society; a manufacturers' catalog data section containing essential and reliable information concerning modern equipment; and complete indexes to technical and catalog data sections.


CUT COSTS 3 WAYS!

WITH

COWLES

SLITTING KNIVES



Cowles knives are so accurate they can be assembled on an arbor quickly with little or no shimming, reducing set-up time. They stay on the job longer, require very infrequent interruption for re-grinding;— and — produce straight edged strip with minimum burr, preventing tie-ups in later forming operations.

For maximum satisfaction, specify Cowles, world's largest manufacturer of rotary slitting knives. Furnished in any face, diameter and bore, in our Max-Cut; Special Alloy; Super Alloy; Circle C; Super C; or any special analysis for slitting high and low carbon steels, stainless, silicon or non-ferrous metals. Prompt delivery!

*Engineering Assistance On Any Slitting Job.*

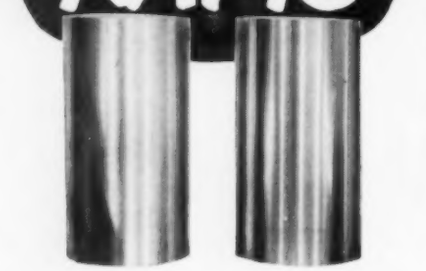
COWLES TOOL COMPANY

2070 WEST 110th STREET • CLEVELAND 2, OHIO

*Specializing in the Manufacture of*

ROTARY SLITTING KNIVES • SPACING COLLARS • ROTARY TRIMMING KNIVES • ROLL TURNING TOOLS • EDGING ROLLS • CUT-OFF KNIVES STANDARD AND SPECIALLY ENGINEERED TOOLS FOR ALL FERROUS AND NON-FERROUS PROCESSING, TRIMMING AND FORMING REQUIREMENTS.

Hyde Park
RAMS



for all types of
HYDRAULIC EQUIPMENT

Hyde Park Rams are available in Chilled or Alloy Iron.

Furnished in hardness range to meet your specification ... ground to your required size.

On your next replacement of Rams — or for new equipment—consult us. Our engineers will be glad to assist you.

**Red Circle Rolls for every Purpose**

**Rolling Mill Equipment**

**Gray Iron Castings up to 80,000 lb.**

Hyde Park
FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland Co., Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

The technical data section contains over 1250 pages, representing an increase of more than 70 pages to accommodate new and revised information. The catalog data section has been expanded, including reference material to 337 manufacturers. Two completely revised and rewritten chapters of especially widespread interest are Chapter 9—heat transmission coefficients of building materials, and Chapter 44—control of the industrial environment. The 1957 edition contains a new set of U-value tables covering many more constructions. Prepared by the ASHAE technical advisory committee on insulation, each table contains an illustration with accompanying calculation on one U-value and an explanation of how to convert U-values to changes in constructions and materials. Chapter 44 is new and covers control of environment and exposure of workers. A new method is described for establishing standards for indicating heat stress. A new chart permits combining the effects of various factors into single heat stress index. The reference list of existing codes and standards has been carefully and fully revised.

**"Abstracts of the Literature on Semiconducting and Luminescent Materials and Their Applications, 1955 Issue,"** compiled by Battelle Memorial Institute, sponsored by the Electrochemical Society Inc., has recently been published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 322 pages, 8½ x 11 in., is cloth bound, and sells for $10.00. Presented in this volume are 1258 abstracts, and these abstracts cover the contributions from the many branches of science encompassed by activities in the field of electrochemics. Materials are the keynote in the organization of the abstracts, providing a more satisfactory system for the compilation. The individual chapters contain several abstracts covering various phases of these materials—germanium, silicon, carbon, selenium, and other elemental semiconductors; intermetallics, sulphides, selenides, and tellurides, oxides, halides, arsenates, phosphates, and tungstates, organics, and theory.

**"Applied Metallurgy for Engineers,"** by Malcolm S. Burton, has recently been published by the McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y. The book contains 407 pages, 6 x 9 in., is cloth bound, and sells for $7.50. This book gives a survey in metallurgical technology for engineers to develop the metallurgical principles involved in casting, metal working, welding, heat treatment, and powder metallurgy, and to study these manufacturing processes from an engineering viewpoint, including the metallurgical factors that control selection of suitable processes, and the influence on the processes on the final products. The contents are presented in 21 chapters. Each chapter is concluded with questions and a list of references. Recently developed processes such as shell molding, inert-gas-shielded metal arc welding, vibrationless mid-air forging are discussed; special topics such as the casting, metal working and welding processes are treated with equal emphasis on both the metallurgical theory and processes. The book is well illustrated using line drawings, photographs, sketches, etc.

**"Boron, Calcium, Columbium, and Zirconium in Iron and Steel,"** by R. A. Grange, F. J. Shortsleeve, and D. C. Hilty, W. O. Binder, G. T. Motoch and C. M. Offenhauer, has recently been published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 533 pages, 6 x 9 in., is cloth bound and sells for $14.00. It is one of a series of volumes the Iron Alloys Committee of the Engineering Foundation, recommended be written. In the series aluminum in iron and steel, nickel in iron and steel, and titanium in iron and steel have been published; and manganese in iron and steel and carbon in iron and steel are in preparation. This volume contains four separate short monographs on the elements used as alloying metals with iron and steel: boron, calcium, columbium (plus tantalum), and zirconium.

**"Steel Plant Refractories,"** second edition (1957), by J. H. Chesters, has been recently published by the United Steel Companies Limited, 17 Westbourne Road, Sheffield 10, England. The book contains 728 pages, 6 x 9 in., is cloth bound,

(*Please turn to page 230*)

## Do you worry about plant expansion wiring costs

# WHILE YOU'RE WAITING FOR A TRAIN?

If you're worrying about the costs of a new power distribution system — either in your present building or in that new plant you're planning — here's one way you can cut down on the worrying. Just specify Rockbestos A.V.C. (asbestos, varnished cambric insulated*) Interlocked Armored Cable. It will not only assure you of dependable service but will help you cut costs several ways. Here's how:

- Rockbestos A.V.C. Interlocked Armored Cable eliminates the need for costly conduits or ducts — it's easily installed on racks or hangers.
- Less layout time — less installation time mean important dollar savings.
- It permits planning for future installations — again at minimum cost.

Add to these direct cost-cutting advantages the long range economy of using a cable that gives you high current carrying capacity, that keeps maintenance at an absolute minimum and you can see the big savings possible when you specify and use Rockbestos A.V.C. Interlocked Armored Cable.

Get full details on dollar saving Rockbestos A.V.C. Interlocked Armored Cable — write now for complete specification and application data.

*Single conductors are N.E.C. type AVA

ROCKBESTOS PRODUCTS CORPORATION

NEW HAVEN 4, CONNECTICUT | NEW YORK, CLEVELAND, CHICAGO, PITTSBURGH, LOS ANGELES, DETROIT, ST. LOUIS, ATLANTA, DALLAS, OAKLAND, SEATTLE

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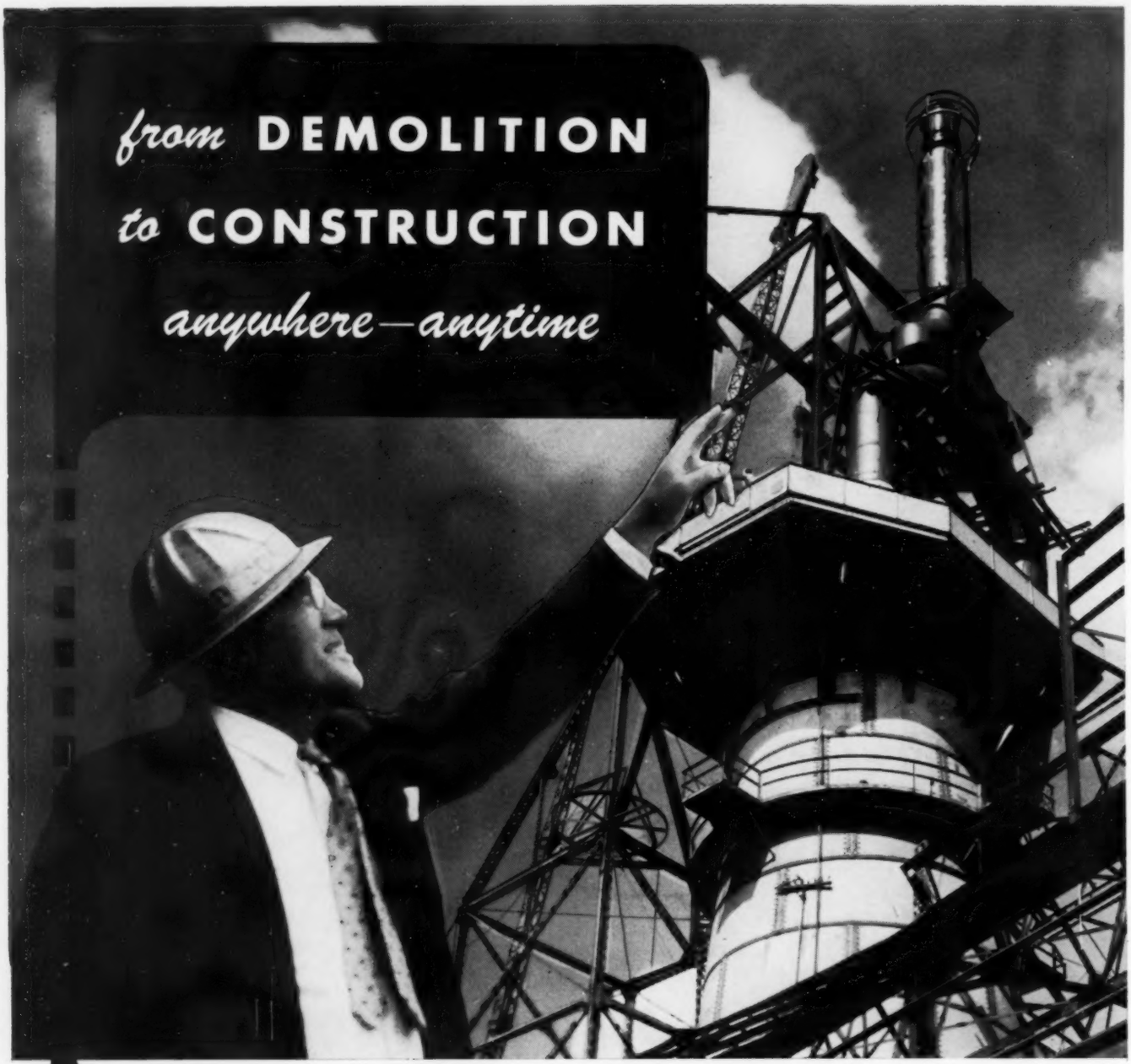


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## Book Reviews

(*Continued from page 226*)

and sells for $12.00 in United States and Canada (including packaging and posting). This edition has been completely rewritten and revised, since the rate of progress in the field of steel plant refractories necessitated a full revision of the data presented in the first edition. The present text provides useful information for operations and together with the excellent abstracts of the British and American ceramic literature should prove an invaluable help in keeping up to date. The contents of this book include: methods of testing, silica and semi-silica; magnesite; dolomite; chrome and chrome-magnesite; alumino-silicates; insulation; the basic open-hearth furnace (above the sill-plate level and below the sill-plate level); the acid open-hearth furnace; acid and basic bessemer converters; the electric steel plant; soaking pits, reheating furnaces and heat treatment furnaces; the casting pit. Also included, by permission of the British Standards Institution, is the new "British Standard Methods of Testing Refractory Materials." A wealth of illustrations, including line drawings, graphs and photographs, as well as numerous tables are used to explain and supplement the text.

**"Der Industrialle Warmeubergang (Industrial Heat Transfer),"** by A. Shack, 5th edition, 428 pages, 6 x 9 in. 72 illustrations, 54 tables, is published by Verlag Stahleisen, Dusseldorf, Germany. This is a clear, understandable book with emphasis on heat transfer in heat exchangers such as steam generators, condensers, feed water heaters, oil heaters, recuperators, and regenerators. About 92 per cent of the 5th edition is a reprint of the 4th edition. The rest is new matter that refers mainly to new research data concerning heat exchangers. With each important equation, the units of the various symbols are given.

The author is part-owner of four companies that make heat exchangers in different countries. He has had, and still has, every opportunity to apply theory to practice. (Reviewed by W. Trinks)

**"Manufacturing Processes,"** 4th edition by Myron L. Begeman, has recently been published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. The book contains 612 pages, 9 x 6 in., is cloth bound and sells for $8.00. The book provides a comprehensive survey of manufacturing materials and processes. Each topic is dealt with concisely and includes casting topics, heat treatment of steel, powder metallurgy, welding, electroforming and coating processes, hot and cold working of metal, press work, inspection—measuring instruments and gages, metal cutting, and machining, gears and gear-cutting machines, and grinding machines. Every chapter has been rewritten for this edition, to bring it up to date with emphasis being placed on recent developments. They are less descriptive than the previous editions, and place greater stress on principles and material; advantages and disadvantages of the various processes are examined.

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# INDEX TO ADVERTISERS

## AUGUST, 1957


A

Aetna-Standard Engineering Co. 1
Alliance Machine Co. 168, 169
Allis-Chalmers Manufacturing Co. 19
Allis Co., Louis 197
Alloy Metal Products, Inc. 146
American Air Filter Co. 27
American Brakeblok Division, American Brake Shoe Co. 179
Atlas Car and Manufacturing Co. 222

B

Babcock and Wilcox Co., The 54
Bailey Meter Co. 183
Bearings, Inc. 213
Berry Bearing Co. 50
Birdsboro Steel Foundry and Machine Co. 185
Blaw-Knox Co., Foundry and Mill Machinery Division 39, 40
Bliss Co., E. W. 194
Bloom Engineering Co., Inc. 223
Bristol Co., The 170
Brooks Oil Co., The 187
Browning and Co., Inc., Victor R. 180
Buffalo Forge Co. 13
Bussmann Manufacturing Co. 152, 153

C

Chemical Construction Corp. 173
Cleveland Crane and Engineering Co. 10
Cleveland Worm and Gear Co., The Cover 3
Cowles Tool Co. 225
Cunningham Co., M. E. 184
Cutler-Hammer, Inc. Cover 2

D

DeLaval Steam Turbine Co. 31
Delta-Star Electric Division, H. K. Porter Co., Inc. 218
Diamond Power Specialty Corp. 181
Documentation and Licenses, Paris, France 2
Dodge Manufacturing Corp. 184
Dowell, Inc. 164
Dravo Corp. 4, 224
Drever Co. 33
Duraloy Co., The 221

E

Eichleay Corp. 21
Electric Controller and Manufacturing Co. Division Square D Co. 12
Electric Furnace Co., The 202
Electric Machinery Manufacturing Co. 201
Electric Service Works, Delta-Star Electric Division, H. K. Porter Co., Inc. 219
Electro Alloys Division, American Brake Shoe Co. 24
Elliott Co. 28, 159
Euclid Electric and Manufacturing Co., The 184
Exide Industrial Division, Electric Storage Battery Co. 220

F

Flinn and Dreffein Engineering Co. 2
Foxboro Co., The 160, 161
Frantz Co., Inc., S. G. 203
Furnace Engineers, Inc. 38

G

Gear Grinding Machine Co. 190
General Steel Castings Corp. 20
Gray Corp., Edward The 228
Guyan Machinery Co. 176

H

Hagan Chemicals and Controls, Inc. 14
Hallden Machine Co., The 2
Harbison-Walker Refractories Co. 8, 9
Harnischfeger Corp. 163
Herr Equipment Corp., The 178
Hyde Park Foundry and Machine Co. 226

I

Industrial Gear Mfg. Co. 15
Ingersoll-Rand Co. 47

J

Johns Manville Corp. 154

K

Kaiser Aluminum and Chemical Corp., Inc. 188, 189
Koppers Co., Inc. 48, 49, 217

L

Larco, Inc. 157
Lectromelt Furnace Division, McGraw-Edison Co. 56
Link-Belt Co. 22, 23, 182
Loewy-Hydropress Division, Baldwin-Lima-Hamilton Corp. 208
Loftus Engineering Corp. 216

M

Mackintosh-Hemphill Division, E. W. Bliss Co. 156
Manning, Maxwell and Moore, Inc. 30
Manufacturers Engineering and Equipment Corp. 150
Mesta Machine Co. Cover 1
Miles and Partner, John, London, Ltd. 2
Morgan Construction Co. 204
Morgan Engineering Co., The 206, 207
Murray Manufacturing Co., D. J. 173

N

National Bearing Division, American Brake Shoe Co. 36, 37
National Carbon Co., Division Union Carbide Corp. 186
National Electric Coil Co. 205
North American Manufacturing Co., The 149

O

Ohio Electric Manufacturing Co., The 18
Ohio Steel Foundry Co., The 174
Okonite Co., The 172

P

Pangborn Corp. 162
Pannier Corp., The 148
Pennsylvania Transformer Division, McGraw-Edison Co. 209
Pittsburgh Engineering and Machine Co. 212
Poole Foundry and Machine Co. 232
Post-Glover Electric Co. 7

R

Ramtite Co., The 177
Reliance Electric and Engineering Co. 34
Rockbestos Products Corp. 227
Rust Furnace Co. 145

S

Salem-Brosius, Inc. 45
Sheffield Corp. 148
Stamco, Inc. 203
Stearns Magnetic Products 46
Sun Oil Co. 5
Surface Combustion Corp. 52, 53

T

Taylor Chain Co., S. G. 157
Taylor Sons Co., The Charles 35
Texas Co., The Cover 4
Timken Roller Bearing Co., The 171
Torrington Co., The 158
Trabon Engineering Corp. 214
Treadwell Co., Inc., M. H. 198

U

Union Carbide Corp. National Carbon Co. 186
United Engineering and Foundry Co. 17
United States Steel Corp. 191

W

Wagner Electric Corp. 16
Wean Engineering Co., Inc., The 2
Wean Engineering Co. of Canada, Ltd., The 2
Wean Equipment Corp. 2
Western Precipitation Corp. 55
Westinghouse Electric Corp. 41, 42, 43, 44, 192, 193
Wheelabrator Corp. 51
Wilson Engineering Co., Inc., Lee 6

Y

Yoder Co., The 32
Youngstown Alloy Casting Corp. 211

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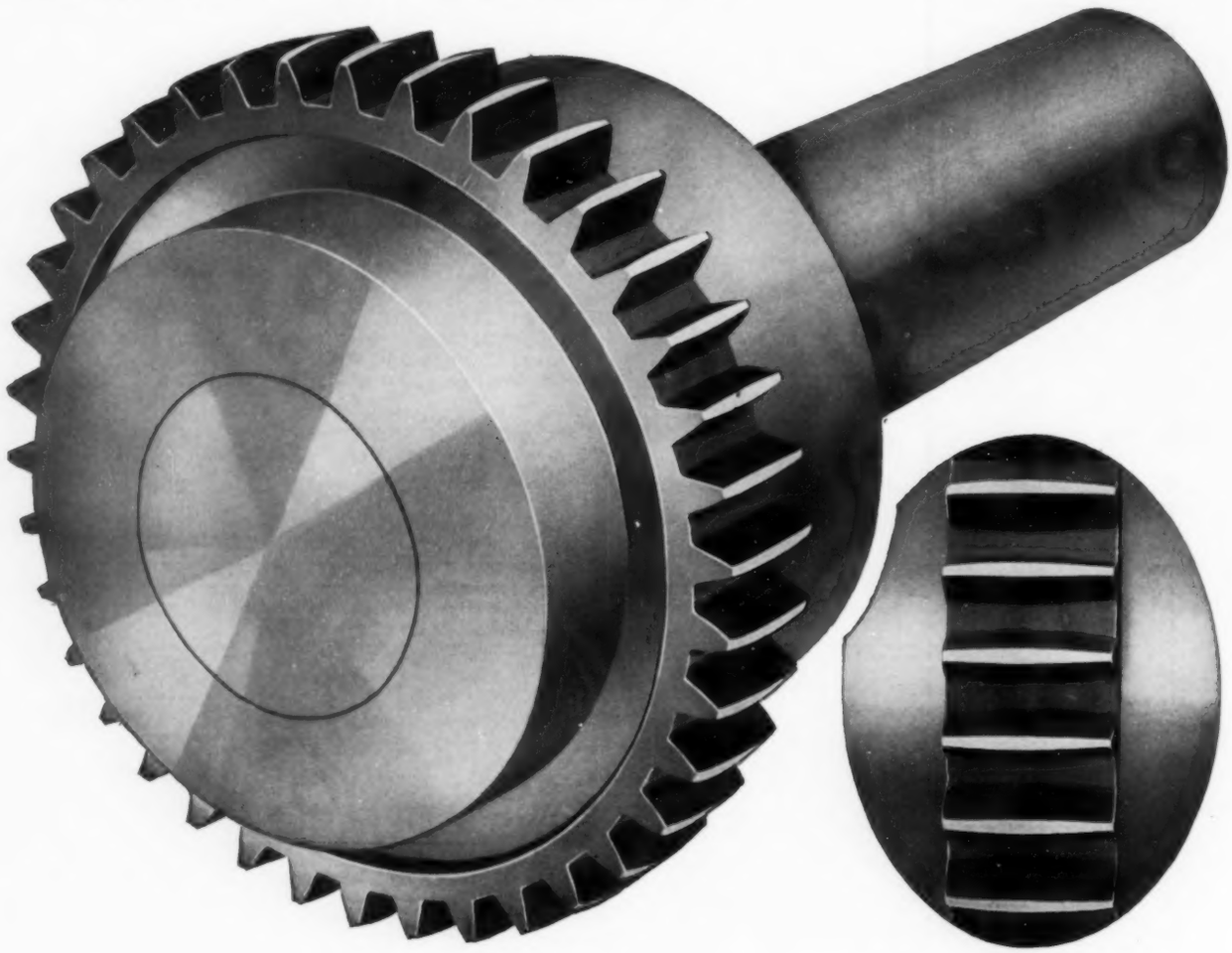

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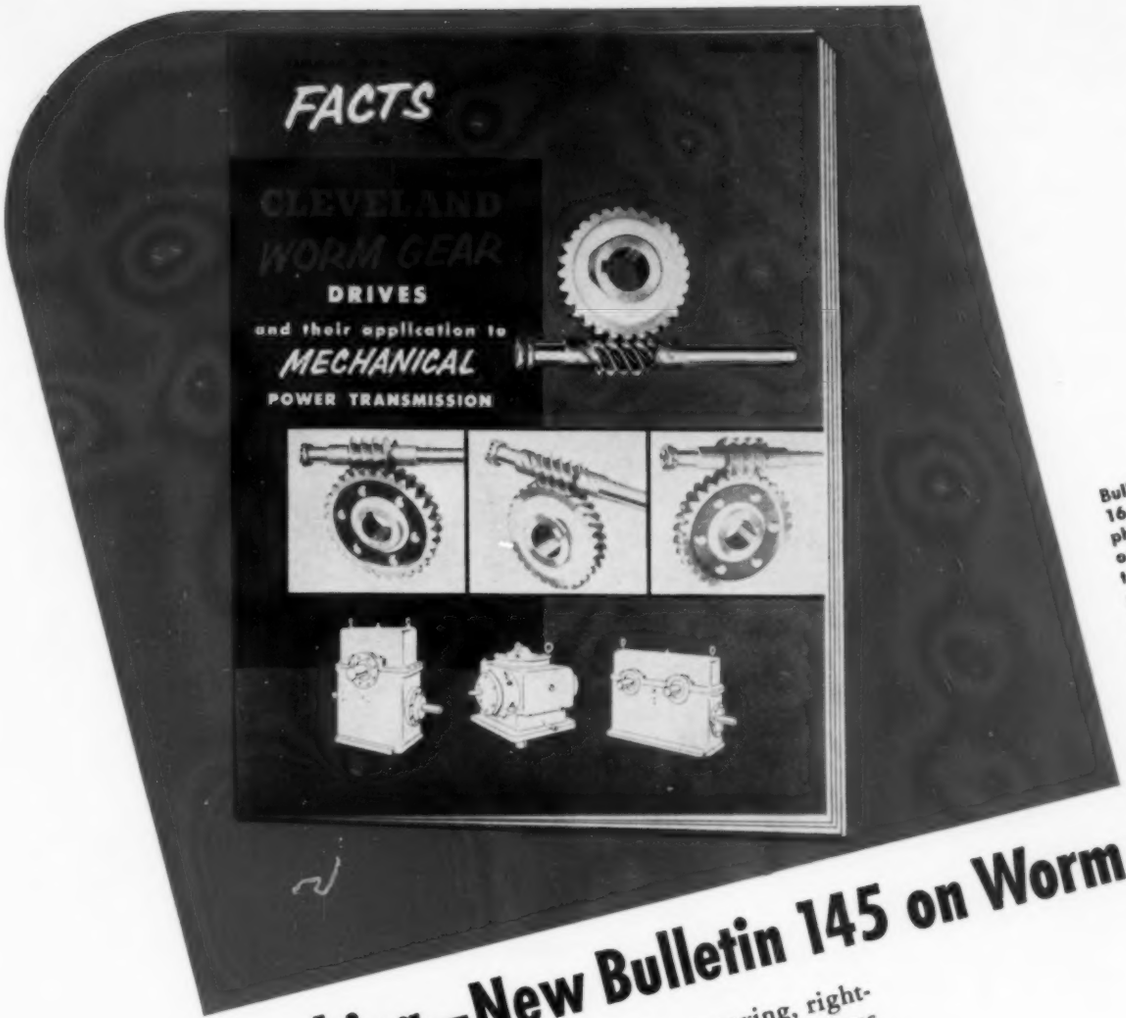


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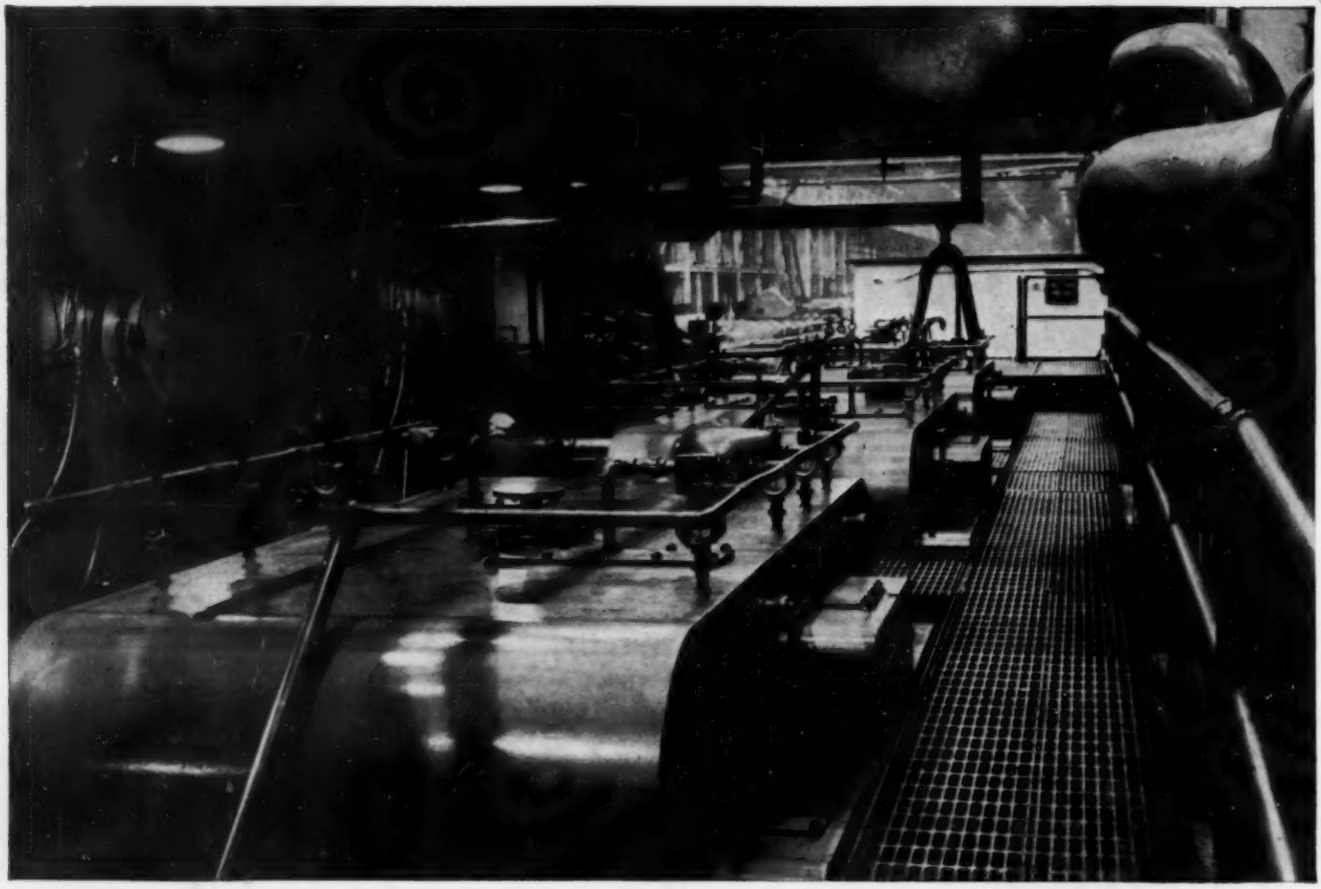

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